Chemical Technology for Appropriate Development

J. van Brakel

Delft University Press

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Cover illustrations

The images on the front and back covers are Adinkra symbols, reproduced from "The Language of Adinkra Patterns", Institute of African Studies, University of Ghana. The symbol on the front is the plural headed crocodile with a single stomach: Symbol of unity in diversity. Democracy, oneness of humanity in spite of cultural diversities. The symbol on the back means 'return and pick it up' : That is, learn from or build on the past. Pick up the gems of the past.

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dedicated to
Professor P. M. Heertjes
on his seventieth birthday

PREFACE

This publication is not a book. It is a report of a small research project carried out at Delft University of Technology within the department of chemical technology. The purpose of the project was to find out whether there exists something called "intermediate" or "appropriate" chemical technology and, if so, in what kind of "appropriate" activities could a department of (chemical) technology at a university become engaged. This report contains a critical review of the literature that was considered relevant to answer these questions.

The contents of the report will be criticized most strongly by development specialists (because I am not an economist or otherwise qualified to write on the subject concerned, and it will be easy to point out how apparent that is), and by those engaged most in promoting "appropriate technology" (because my criticism of the appropriate-technology-bandwagon is neither "constructive" nor "based on facts"). Multinationals, the UN-family, and other capitalists are so used to criticism that I am sure they won't notice mine. Chemical engineers or other technologists will have no opinion on the contents, because they don't read all the economic and political nonsence that non-technologists say is relevant to technology. However, the report will certainly be of use for some student as a source book for literature references, quotations, definitions , and ideas.

This report does not contain any paragraph or chapter in which conclusions are drawn. Although the reader will soon discover that the report is full of sweeping and non-supported generalizations of fact and value, this is only to be considered as an embellishment. My intention was to provide a large information density per subsection (inevitably selected and structured by my implicit value judgements). The serious reader should attempt to study the report and then make up his own mind. Then, he should put his opinions onto paper and reread (or rewrite) the report. I, for my part, have not been able to form a coherent opinion about the problem of appropriate processes of change, but I keep trying.

When people disagree, they often refer to the distinction between criticism that is contructive and that which is not. I have never fully understood the nature of this difference. Certainly, to the way science or technology changes (some would say: makes progress) or to the way political factions or powers take over, this distinction is not relevant. My critical comments are just what they are: criticisms of (i) statements (as I understand them), and (ii) structures and processes (as I observe them). I hope every reader will accept that my criticism is not levelled at persons and their motivations and commitments.

Acknowledgements

There are a number of ways in which this project was made possible. Professor Heertjes, under whose formal supervision it has been carried out, made it possible for me to spend a significant amount of my time on it. Apart from a grant by the Hoogewerff-foundation to visit Britain in the early days of the project, all expenses (including significant travelling costs) were paid out of the regular budget of my department. During the first six months of the project ir. R.P.M. Spronk assisted with gathering and cataloguing literature and also carried out a number of interviews in The Netherlands. For the other 18 months mr. D. Hoeksema processed the flow of literature into some accessible order.

All interesting ideas in the report are taken from the literature, as the reader will easily discover. I have tried hard always to indicate this and my acknowledgement to various authors should be

apparent from the number of times they are quoted or referred to. Further, I have benefitted from "IWAPS"-discussions with ir. R. Königel and mrs. drs. S. Wassenaar-Farr, as well as from comments of dr. A. Kapteyn, ir. A.G. Montfoort, and mrs. B.A.C. Saunders on parts of the manuscript.

The conglomerates of strangely formed ink blots I produced have been transformed into the typescript here reproduced by the "Afdelingsbureau" of this department, an administrative collective that seems capable of solving all problems, least of all mine. Finally, the Committee for International Co-operation Activities of this university made it possible to send copies of the report to the many contacts in developing countries who made the project possible by sending information and/or giving interviews on their activities or opinions.

Delft, November 15, 1977

CONTENTS

1. CHOICE OF PRODUCTION SYSTEM

1.1 Production systems

1.1.1 Technology and production system. A lot of semantic, and sometimes ideological, confusion with respect to some kind of "technology" is due to the fact that in the English language "technology" is often used in the sense of "production system", or even "machines". It is preferable to use the term "technology" only when "(scientific) knowledge of production systems" is meant. And that is what I shall do in this report[1]. Economists tend to use "technology" and "techniques" interchangeably, e.g. one finds in the literature both "choice of technology" and "choice of techniques". I shall use "choice of production system". I reluctantly use the term "system", because it has acquired some odd connotations due to the influence of the so called "general systems theory"[2]. Unfortunately, at present I see no better alternative

1. 'I would only add here that you could perhaps stress the importance of what to many may seem a semantic triviality. Certainly in the area of economics it *does* matter what you call things. There is an overwhelming tendency among economists to discuss problems about techniques (production systems) and technical (systems) change, and then shift off to discuss what should be done in terms of techn*ology*-manipulating activities - e.g. more R & D, usually R. Many of the problems are more proximately related to weakness in handling the actions and decisions about techniques (systems) than generating *more* knowledge (logos) i.e. They are as much (perhaps) more to do with *using*-ology than creating it.' (Bell, 1976, personal communication.)
2. About systems theory it is said that 'it offers scholars, educators, engineers, and artists new and harmonious ways of looking at the world' (Klir, 1972, Preface); 'system engineering is the utilization of science for the benefit of man', because it takes into account the 'interaction of the particular technology with the total system in which it is to be used', so as 'to develop a technology both matched to all the people and to the society it serves, and responsive to the national goals' (Truxal, 1972, pp. 1-3). I am of the opinion that systems theory can be best described as the metaphysics of technocracy. Therefore, I would like to stress that by using the term "system", nothing is im-

to its use. This report then is concerned with production systems. A production system[3] is described in terms of:

(a) the raw materials, the (mechanical, physical, chemical) operations, processes and apparatuses used, as well as the products obtained;

(b) the individuals and institutions[4] that are necessary to have the system produce;

(c) the interaction of the system with the physical and social environment[5] (including macro- and long term effects).

Production techniques are the methods used in making the system produce; it includes not only the operations or material treatment steps, but also marketing, management, accounting and such like[6]. In restricted contexts "production techniques" and "production system" may be used

plied about the methodology of technology. This is necessary, because if the term production system is used in the literature it usually implies this systems-belief-system, e.g. Bertholet and Gaillard (1974, p. 24): 'een gestructureerd geheel van samenstellende factoren, dat, geleid door een eigen complex van doelstellingen en attitudes binnen het bredere kader van de maatschappij een (of meer) economische functies vervult (productie van goederen en diensten).'

3. The properties of complex entities such as production systems can be ordered in numerous ways depending on one's purpose and preoccupations. Compare with (a) - (c) given in the main text: A production process has four components: resources, people, technology, economic and political structure; any of them can stop the process of producing or starting to produce (Hvelplund, 1974). The main characteristics of production systems are: product type, product nature, scale of production, material inputs, skilled and unskilled labour input, managerial input, investment requirements (Stewart, 1977, p. 2).

4. I shall use the term institution mainly in two related meanings: (a) a significant and persistent element (as a practice or an organization) in a culture that centres on a fundamental need, activity or value and occupies an enduring and cardinal position within a society; (b) an established society, foundation, firm, organization or corporation, including governments, international organizations and such like.

5. "Environment" as used in this report, always refers to *all* surrounding conditions and influences that may effect the production system: physical, ecological, social and cultural conditions. I use "environment" when the emphasis is on the enduring interaction. I shall use "context" - also referring to the interrelated conditions in which something exists or occurs - when the emphasis is on one particular moment, for example: making a decision in a given context. The properties of environment and context are boundary conditions for the individual or institution considered.

6. Marketing refers to all the processes required to make goods available to the consumer in the form, at the time, and at the place he is pre-

interchangeable[7].

Technology includes all knowledge about production systems. Technology is the know-*how* to use various production techniques in order to produce, plus the know-*that* particular production systems affect both the individuals taking part in it, and the environment, in a particular way: it is not to be identified with the applied physical sciences. The technology that is developed at a particular time and place is subject, as a matter of course[8], to socio-cultural influences. Typical areas of impact are: equipment (e.g. psycho-motor response), product (e.g. food preferences and taboos), working group attitudes, entrepreneurship and innovation. That is, the properties of a production system do not only depend on physical and strictly economic boundary conditions, but also on such things as the ideas of the people involved and the given institutional and political system[9].

In relation to the question as to whether a production system is

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pared to pay for it. Accounting is the method of recording the money value of business transactions in order to show their effect upon the financial position of the individual or institution conducting them. Management refers to the executive function of planning, organizing, coordinating, directing, controlling, and supervizing any production system with responsibility for results.

7. In one production system (soap manufacture) a large number of techniques are used (drying, labour management, advertising). One technique is used in many different production systems: drying of soap, bricks, peanuts. Using technology both in the sense of the 'methods used in non-marketed activities as well as marketed ones' (hence, the sum of all techniques) and in the sense of 'a series of techniques' (hence, the sum of all production systems), as Stewart (1977, pp. 1-2) does, is most confusing. ('Each technique is associated with a set of characteristics", including "the nature of the product, the resource use - of machinery, skilled and unskilled manpower, management, materials and energy inputs - the scale of production, the complementary products and services involved etc.')
8. 'One of the most serious misconceptions in contemporary thinking is that technological development is a pre-determined process which must follow the lines of its growth in western civilisation. Since technology as much as art is an expression of human activity it should reflect the social, ideological and intellectual climate existing in a specific time in a specific place. Thus a concept of technological pluralism must of necessity replace the present concepts of technological monism' (De Silva, 1974.)
9. There is the usual problem of the precise difference between economic, psychological, social, socio-psychological, cultural, socio-cultural, political, anthropological and other factors, while everything is in some way historical. I try to use "economic" and its derivations always

possible or appropriate in a given environment or not, I shall further use the following descriptive terms: A production system can be technically possible, technically efficient, economically feasible, economically efficient, and socially or culturally appropriate - or just the converse of all these. These terms will all be elucidated in subsequent sections. Further, I shall say that, by definition, in order to have an economically feasible and culturally appropriate production system certain socio-psychological and institutional requirements have to be fulfilled. The institutional requirements include services such as banking and education.

1.1.2 Institutions involved. A small family living in isolation, of necessity being self-sufficient, uses many production systems, but no formal institutions. In an isolated village, production will be embedded in the traditional institutions of the particular culture. But nowadays isolated families and villages are rare, and at least potentially, all productive units in the world are related to units[10] engaged in the supply of technology (such as research centres and service laboratories), service units (such as markets, financing corporations, producer's associations and training centres), as well as linkage units (extension

in the narrow sense of positive economics: 'the science which studies human behaviour as a relationship between (given) ends and scarce means which have alternative uses', using as given data, not to be further analysed, the available production techniques (often restricted to only those in use), the individual demand curves, the natural resources and environment, the legal and political structure. Psychology is the science of human behaviour, including underlying explanations in terms of attitudes, values, etcetera. Social-psychology refers to behaviour in or under the influence of groups. Social and cultural I tend to use interchangeably; they include everything that is left, also political history, institutionology and development theory. In stead of "the given institutional and political system" I could as well have written "the given social, cultural, socio-cultural, socio-anthropological and so on system", while marxists should read "the given Economic system".

10. IDRC (1976) gives a useful inventory of the types of organisation that come under productive, supply, linkage and service units, although their analysis is biased to large-scale production units and their environment. See further section 2.2 on S & T policy.
11. Infrastructure refers to the basis services needed in a modern economy: transport, power, water, education, health services, housing. When the emphasis is on the capital assets that provide the services, infrastructure is also called social overhead capital. Cf note 4 on "institution": the notions overlap.

units, documentation centres, and consulting firms). The more sophisticated a production system becomes, the more it is dependent on a complex infrastructural[11] and institutional framework. With growing complexity, the discrepancy between the available technology, i.e. the available knowledge of production systems, and the actually existing units will increase to the extent that it becomes impossible to evaluate this discrepancy.

1.1.3 Chemical production systems. In a chemical production system materials undergo changes in physical and/or chemical state, in order to produce the desired product. In this report "chemical technology" is used in a rather wide sense, including most of building materials, biochemical, mineral, and post-harvest technology, but not agricultural, power- and strictly mechanical technology. In chapter 5 a more detailed delineation will be given.

In the terminology used here, chemical engineering[12] is part of chemical technology, in that it is defined as the development of techniques and the design and operation of plants in which chemical production takes place on an industrial scale. Typically, a chemical plant[13] is made up of units such as vessels, pumps, boilers, and towers - and therefore chemical technology, which mainly is about what is happening to the materials in these apparatuses, is closely intertwined with part of mechanical technology, which is concerned with how to make these apparatuses. Chemical production systems use as (capital) input the output of mechanical production systems.

A very important role in the development of chemical industry is

12. Economists usually restrict the meaning of "engineering" to 'the work done to bring a project to the point where all the detailed drawings are completed and equipment specified to meet the client's requirements' (Freeman, 1968).
13. 'A chemical plant handles materials in a bulk state, solid, liquid, or gas, and performs physical and chemical operations on them, finally packing the products in a suitable finished form. The equipment is made up of units which are common for many processes and products throughout the industry, such as vessels, pumps, boilers, electric motors, towers and so on. The operating labour force is rarely engaged in repetitive manual tasks except in the packing and warehousing sections.' (Arãoz, 1961.) The main characteristics of the modern chemical industry are: large units, high R&D budget (expansion), trusts (to reduce risks), capital intensive, bulk production, highly interrelated (joint ventures, licensing).

played by so called contractors or engineering firms[14]. Before the war chemical firms normally designed their own plants and obtained their tanks, columns, compressors, valves, etc. directly from the metal fabricating and engineering industries. This situation has now changed drastically. Most of the major new plants are now engineered, procured and constructed by specialist plant contractors. The chemical plant contracting business is dominated by American firms, mainly because of the major process innovations they made[15].

1.2 Appropriate production systems

1.2.1 On adjectives. The number of adjectives attached to "technology" (read "production systems") to indicate that something else than normal technology is meant, is still growing. I have come across the following:

(a) appropriate, correct, optimum, adapted, mixed, pluralistic;

(b) labour intensive, low-capital[16], low-cost;

(c) intermediate, small-scale, small capacity;

(d) rural, survival, self-help, bare-foot, third, peoples', indigenous;

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14. The terminology is not consistent. One way of ordering is (IDRC, 1976, p. 62): 'In the case of the engineering firm, it is possible to differentiate three types, even though these are often present in a single firm. There are the *consulting engineering firms*, which deal mostly with the economic feasibility of industrial, mining, finance, or trade ventures. They may even go to the level of preassembling an industrial project, putting together the definition of products, basic technological layout, and capacity selection, omitting only the actual engineering work. This is usually performed by the *design engineering firms*, which make the basic and detailed design of the industrial plant that is to be established. The third category, *the service engineering firm*, has a wide variety of functions related mostly to the implementation of projects: choice and negotiation of technology, selection and contracting of engineering work, selection and purchase of equipment, selection and contracting of personnel, administration of the industrial project, supervision of subcontracted work, and start-up management.'
15. The role of the contractors is especially important in the export market. One may expect a strong correlation between country of design engineering and country of hardware procurement and this is in fact the case (Freeman, 1968). Of course a contract may specify that local procurement of various items is required. Freeman also found a close association between export success and national origin of process know-how.
16. also: "light-capital", "capital-saving", "light engineering".

(e) alternative, liberatory, progressive, alternate, radical;

(f) clean, soft, eco-.

Many of the adjectives have no descriptive content: usually what is said is a tautology, whereas the writer tacitly refers to some value judgement. That is to say: That, given a number of boundary conditions and specified goals, one should choose the right (= correct = appropriate = good = adapted = optimum) production system (to be developed) is not a very original idea. The question is

what are the boundary conditions (and can *they* be changed),
which goals have to be chosen (and by *whom*),
what *then* is the best production system, and
how can it be put into operation.

These five or six or more questions each give rise to their own peculiar problems and more details can be added[17]. For example, with respect to the relation of a particular production system to a particular goal one may specify the effect of the boundary conditions on the implementation of the production system by distinguishing: the technical possibility, the economic feasibility the available and necessary institutional requirements and the cultural constraints. I shall, however, use in this report the above six questions as the major ordering mechanism and will refer to them without further indication as "the questions".

The adjectives under (b) and (c) can be given a purely descriptive meaning and these will be introduced in section 1.5 when production factors, such as labour and capital, and economies of scale have been discussed in sections 1.3 - 1.4. Also in section 1.5 the dichotomy rural vs urban and indigenous vs foreign will be elucidated[18]. The other adjectives mentioned under (d) - (f) are not further discussed.

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17. Compare Stewart (1972) on 'the best way of organizing production in an economy. This will be a function of: 1. The initial and historically determined way in which production is in fact organized.... 2. Different possibilities available in the current state of knowledge.... 3.The resources available to the society. 4. The aims of economic policy.' Note that this is exactly the data on which positive economics is usually based. Therefore, in my opinion one of the most important questions "Can the boundary conditions be changed?", tends to be overlooked, although Stewart herself has been a strong advocate of this question; see in particular her distressing conclusions in Stewart (1977).

I assume that the reader can generate some idea of their connotation[19].

The terms most often used are "appropriate" and "intermediate", the

18. In this chapter I deliberately refrain from talking explicitly about production systems for developing countries. It may, however, be useful at this point to quote Stewart (1972): 'Underlying discussion of this subject, irrespective of terminology are three thoughts: (1) that developing countries should adopt technology apprpriate to them; (2) that the appropriate technology, whatever it is called, is different from the technology of the developed countries, and different from traditional technology...; (3) that the special technology, which I shall call IT, is *not* at present being introduced in developing countries to an appropriate extent, and that a special effort of some sort is required to get it introduced.' The factors mentioned under (2) and (3) will be discussed in sections 1.5 and 1.6 without explicit - although many implicit - references to developing countries.

19. Roughly speaking the adjectives under d) refer to humanistic values: *survival technology*: 'for the hundreds of millions of farmers left out of the development process' (Hoda, 1974). 'Appropriate technology must benefit the largest number of people possible, i.e. distribution of surplus production at the lowest possible level.' (Garg, 1975); 'a third technology which consists of an adaptation of modern methods to the special conditions of the developing world' (Mathur, 1968). See on self-help e.g. O'Kelly (1973) and references given there.
The notions under (e) are of a purely political nature and are defined in opposition to the prevailing use of technology (by the prevailing powers in society). For example: '... the word "radical" literally means "going to the root", and accordingly "radical technology" implies a fundamental re-examination of the role of technology in modern societies. It also implies a commitment to the ideals of the political Left.' (Harper, 1976.) Maybe soft technology should also be classified in group (e), e.g. Brouwer and Miedema (1975) mention criteria such as "non-alienating". For neo-marxists appropriate technology as usually understood is just another variant of the capitalistic ideology because: 'It ascribes the same neutrality to technology in the development process ... it is not claimed that past policies have been proved wrong, but that economists have been insufficiently sophisticated in their evaluation of technological needs, failing to take into account a wide range of social and cultural, as well as economic factors.' (Dickson, 1974, p. 151f.)
The notions under (f) are mainly used with reference to industrialized countries. Often they are related to the notions "limits of growth" and go back to the *Blueprint for survival*. 'As the new technology developed, it has become increasingly clear that the old Faustian dream of endless "progress" towards man's total domination of the earth has not been fulfilled.' (Mackillop, 1975.) "Nature knows best" (Clarke). Probably under the influence of the UN Environmental Programme ecological considerations are becoming more influential with respect to developing countries. See Farvar and Milton (1972) and Romanini (1974). 'Clean technology implies not only a technology that does not pollute (materially:air, water, earth; noise; thermally; etc.) but also it is fre-

former now gaining universal prominence[20]. Both terms may imply one or more of the other adjectives as is clear from the definitions given in

quently used to describe a technology socially desirable, that is, one that helps to redistribute income, decongest urban areas, help man maintain (rather than lose) his individual personality, etc.' (Giral, 1972, p. 63.)

20. The following distiction between "intermediate" and "appropriate" as made by Giral (1972, pp. 61-62) is representative for most of the literature: *'Intermediate technology* - This term, because of practical use, has been accepted to define a technology in between the traditional - primitive technology, unchanged in centuries, being used in most rural sectors of the industrialized countries and that in use also in the urban and some high level rural sectors of developing economies. The theory behind intermediate technology is that such an intermediate step is needed if one really wants to foster development in the areas described above, otherwise, the jump from traditional technology to modern technology is so big that many societies can not do it.
Appropriate Technology - A technology appropriate (adequate, convenient) to the set of conditions and requirements of the environment where such technology will be used. The terms adequate technology, convenient technology, can, in our opinion, be used interchangeably. The term optimal technology, on the other part, represents a refinement on the others implying that the technology has been selected according to precise mathematical criteria of optimality and that there is certainty (at least statistically speaking) that such a technology represents.'
From the many other definitions of "appropriate" occurring in the literature I have selected the following:
Appropriate technology can be looked upon as an approach to supplying technology to a society that requires it. The choice of a technology that is appropriate should be made on the basis of the types of production, availability of manpower, size of market, and other social, economic and cultural considerations. In rural development, appropriate technology, even if it is a simple technology, might be new technology derived by research. Therefore simple technology does not always imply obsolete technology imported from elsewhere. The general policy bias in relation to appropriate technology is that it should promote employment wherever possible.' (DSE, 1972.)
A technology which can carry out production on the smallest possible scale and yet can produce the same quality product at a competitive price compared with that of large-scale industry.' (Garg.)
Briefly, the most appropriate technology is one that directly meets people's needs, is consistent with local values and environmental concerns, and can be controlled, managed and maintained by local materials, resources and expertise.' (VITA, 1976.)
Technical definitions are scarce: 'Appropriate technology may be defined as the set of techniques which makes optimum use of available resources in a given environment. For each process or project, it is the technology which maximizes social welfare if factors and products are shadow priced.' (Morawetz, 1974, p. 517.) The advantage of trying to give more technical definitions is that criticism becomes easier, hence elucidating underlying problems. Morawetz definition is criticized by Stewart (1977, p. 95) because 'This definition takes as given the set of

the literature[21]. The terms "optimum", "mixed", and "pluralistic" emphasize that a priori anything can be appropriate . In subsection 1.2.3 I shall give a list of criteria that have been suggested to check

techniques available, and defines appropriate technology as the best choice within the available set, using shadow prices to select that best choice. The definition is open to two objections. First, it implies that society may arrive at a unique set of social shadow prices to select the optimum technique. In reality conflicts between different parts of any given society mean that different groups have different objectives, which discredits the concept of a single set of shadow prices and a single optimum. Secondly, and particularly important in relation to discussion of technology, is the mistaken assumption of a given set of techniques. The main point of the discussion of appropriate/inappropriate technology is thereby missed; as argued earlier, the whole thrust of technological development has been such as to create an entire set of inappropriate techniques, and to leave undeveloped and underdeveloped the techniques which suit the conditions in poor countries.'

21. Nowadays "appropriate" is often subdivided in a number of quite different types of systems and accompanying value systems. Representative examples are, for overdeveloped and underdeveloped authors respectively, Collombon (1975) and Singh (1975). The latter distinguishes *intermedidate* ('Developing countries with large surplus of labour and scarcity of capital resources must adopt technologies which are capable of generating employment for large numbers but require little capital. Examples are particularly given of agro-industries where design of equipment could be improved upon without excessive mechanisation. There is plenty of merit in the idea of intermediate/appropriate technology provided its limits are understood and its pattern is kept as a stepping stone to adoption and acceptance of modern technology'), *down-scaled* ('It advocates smaller sized plants dispersed in various areas with a bias against sophisticated, large scale capital-intensive plant. The examples are given of the small sized cement, paper and sugar plants. While prima facie it would appear that setting up of the small sized plants would be economically advisable and even desirable, no work has been done on the techno-economic examination or study of such plants in particular situations. Here again, danger of acceptance of smallness as a virtue rather than an economic expediency is likely to prove detrimental to both'.), *appropriate design engineering* ('The relevance of the concept is that industrial entrepreneurs in a developing country and a sellers' market looking for quick profits are more prone to ignoring the different parameters in regard to appropriateness of technology. The technology/equipment imported may be unsuited to national conditions, indigenous resources or other endowment factors. Local new materials, minerals and agro products may lie unutilised. The entrepreneurs and their foreign collaborators may encourage import of components and raw materials of specifications relevant to the country from which the technology is imported.'), *alternate* ('The concept of alternate technology is actually of making a choice appropriate to the social needs of the largest number particularly where State investment and policies are involved.').

whether the production system is appropriate. First we turn to a brief historical digression to provide some perspective.

1.2.2 History of 'intermediate' and 'appropriate'. The term "intermediate" was coined by Schumacher while consultant to the Government of India in 1963[22]. Intermediate technology should provide a way of dealing with mass rural emigration, mass unemployment and mass undernourishment[23]: industries should be set up of a type suited to rural areas, located in and supplying the needs of rural communities. In 1964 the first conference on intermediate technology ever held took place in Hyderabad. Significantly the conference proceedings are entitled "Appropriate Technology for Indian Industry": 'Right at the time of this invitation we had signalled we did not like the term "intermediate". We hope that the term "appropriate" technologies will now replace it. "Intermediate" suggests a stage on the way to something better and is therefore confusing. The real problem is to develop in India technologies which are appropriate to India, i.e., technologies which are the very best in the context of India's circumstances, situations and resources. Technologies appropriate to India - with its low wage rates, millions of unemployed and the continuing shortages of capital, foreign exchange, certain raw materials and specialised skills, which accompany rapid development - are necessarily different from technologies appropriate in countries where capital is plentiful, labour highly paid and large markets are open to an ever changing array of consumer and capital goods. The implications of these differences in conditions for

22. 'The concept of appropriate or intermediate technology was introduced by E.F. Schumacher in a report to the Indian Government' (Reid, 1973). I have not consulted this report. The adjective "appropriate" has no particular origin, because it just means what it means. Stewart has found the appropriate use of appropriate already in a publication of 1955 and with some difficulty it will be possible to find a similar quotation with, say, Cicero. ('A country which cannot hope to reach within a foreseeable time a capital supply equal per head to that of the United States will not use its limited resources best by imitating American production techniques, but ought to develop production techniques appropriate to a thinner and wider spreading of the available capital.' (Hayek and Lachman, 1955, p. 89.))

23. The political climate was relatively favourable for this approach: 'Just keep one thing in mind, when you are taking any action or making any decision, try to judge how this action or decision is going to effect the poorest of the people.' (Mahatma Gandhi) However, the subsequent five year plans of India have always been biased to the big-jump modern industrialization philosophy.

technologies - and also for forms of industrial organisation - remain to be explored.'[24]

From the very beginning the term "intermediate" acquired the connotation of "inferior" in developing countries.[25] Nevertheless for quite some time "intermediate" was used more frequently than "appropriate", because Schumacher, together with others, founded in 1966 an organization called *Intermediate Technology Development Groupe* (ITDG),[26] followd in 1967 by the Indian *Appropriate Technology Development Group*. ITDG quickly gained momentum. In December 1967 its first major publication "Tools for Progress" was launched. In January 1968 the first conference on intermediate technology in the U.K. was held in Oxford, with the purpose to consider 'the further development in the United Kingdom of appropriate technologies for, and their communication to developing countries'. In the same year a similar conference was held in Rome.[27] The breakthrough of the appropriate technology movement can

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24. remarks R.N. Jai, Principal Director of the SIET institute, which organized the conference (SIET, 1964). In Schumacher's contribution to the conference the term "intermediate" plays no dominant role but he leaves no doubt that 'it is erraneous to think that for an underdeveloped country, the introduction of the highest level of technology is the best; that "high productivity", attained here and there through such an introduction is better than nothing. It is in fact worse than nothing.' (SIET, 1964, p. 36.)
25. 'It is however necessary to clarify that intermediate technology is essentially a transitional technology especially relevant to emergent economics. It should not and must not imply an "inferior technology", but must reflect the cultural background of its operatives and the ability to develop further to the highest state of technological advancement in the particular context. In our opinion it is wrong to conceive of "intermediate technology" as a means of postponing the econo-cybernetic change-over.' (De Silva, 1974.)
26. See chapter 4 for a fuller description of the activities of ITDG.
27. "Congrès sur la technologie intermédiaire dans le développement" (Caritas, 1968): 'Le Congrès avait pour objet l'étude du développement de l'homme par l'homme et se proposait de considérer avec une attention toute particulière la stratégie de la technologie intermédiaire par le moyen de quoi l'homme des pays développés peut inspirer et véritablement animer l'homme des pays moins développés, le poussant à un engagement plus profondément effectif en vue de l'actuation de son développement propre.', and was addressed by Pope Paulus VI: 'Vous discutez actuellement de la direction à donner aux efforts d'assistance au Tiers-Monde et, en particulier, de la nécessité d'aider les individus de cette partie du monde, tels qu'ils se présentent à nous, dans la situation qui est véritablement la leur et sans omettre de considérer les circonstances qui la motivent.'

be situated in 1972. On instigation of ITDG a *Technology Consultancy Centre* was established at the University of Science and Technology in Kumasi, Ghana and an international conference on appropriate technology sponsored by the *Deutsche Stiftung für Entwicklungshilfe* was held there (DSE, 1972). The OECD organized a conference in Paris on the "choice and adaption of technology in developing countries", where much attention was given to appropriate technology. The UNESCO adopted a resolution on appropriate technology.

Already in 1971 the *World Plan of Action* had been published (UN, 1971), in which an important place was reserved for appropriate technology. Although it has never, as such, been accepted by the United Nations General Assembly, in subsequent years all UN-organisations involved in production systems in any way had to adopt appropriate technology as their major policy. I shall describe this development and the actual effect it has had until now, more fully in chapter 3. At this point it should suffice to emphasize that at this moment "appropriate" has lost any descriptive meaning it may have had.

Banjo[28] has summarized in an excellent way why the term "intermediate" disappeared and "appropriate" came to mean at least two quite distinct things. In theory "appropriate" is seen as the compromise between the pros and cons for intermediate technology, the advantages being that it was simpler, easier, more labour intensive, and less disruptive of social structures. The other side argued that:

(a) 'if people had to learn new technologies, they might just as well learn the most modern and effective ones'.

(b) 'The final cost per unit of product often turned out higher'.

(c) 'Only by raising productivity can employment be increased'.

(d) 'Development implied social change and there would be dislocation anyway'.

All these arguments will be discussed in more detail in this and subsequent chapters. In finding the compromise, terms such as optimal,[29]

28. Quotations from Banjo (1974), which is an excerpt of Banjo, in: DSE (1972).
29. The term "optimal" is used in particular by the (British) Tropical Products Institute: 'TPI's target is the "Optimal technology". The basic thesis in this is that each requirement has to be considered individually. The "Optimal technology" in each situation is then *not* determined

pluralistic and mixed have come into use, to indicate that what is appropriate, depends on circumstances given. But with a compromise in terminology the schism in thinking has not been resolved. Nowadays "appropriate" usually means "simple intermediate technology" for those focussing their attention on rural development, and "the most effective technology" for those interested in modern industrialisation.

1.2.3 Criteria for appropriateness. Hvelplund has probably made the longest list of criteria appropriate technology has to meet.[30] The problem with the long lists of "good things" is, that it does not follow in any way whatever, how incompatible criteria have to be combined. The problem with short-lists of criteria is that it is never clear whether the list is meant or thought to be exhaustive. For example, if it is not mentioned that an appropriate production system should be economically feasible, does it follow that that is irrelevant ?[31] In Table 1 most of the criteria that have been mentioned in

by any general economic or sociological theory; it is *not* limited to any degree of sophistication, scale of operation, labour intensity or cost; it is *not* seeking in any sense a second-rate solution; but it is *the best* technology that can be advanced or devised to meet the individual requirement, taking full account of all the relevant local political and other factors, particularly the need to maximise social and economic benefit to the community and to make best use of local entrepreneurship, management personnel, skilled labour, unskilled labour and such funds as may be available.' (Spensley, 1974.)

30. Hvelplund's (1974) criteria as ordered by De Wilde (1975) are 15 in number and take more than 200 words to summarize them. Similar criteria are given in the review article of Collombon (1975). They are ordered more systematically in four groups of characteristics: socio-political, technico-economical, psycho-sociological and ecological.

31. Because of all the non-paid activities of voluntary organizations commercial viability is not a very prominent characteristic in the literature. 'So far most discussions on appropriate technologies have been based on considerations such as labor intensiveness, lower capital-labor ratio, local skills and materials utilization, etc. The inherent danger in following such an approach is that we may impose technologies that may not be commercially viable in the developing countries. Development policies should certainly encourage labor-intensive technologies in the developing countries; however, selection of technologies without due regards to the market considerations could be quite a wasteful exercise. The marketability of products and services of technologies must be the overriding consideration in the selection of appropriate technologies for developing countries. Discussions on appropriate technology must, therefore, begin with an assessment of the primary needs of the local population, the demand for products and service to meet these needs, and a subsequent analysis of the technologies that could economically cater to these demands through an optimum use of local resources.' (Khan, 1973).

TABLE 1. Possible features of appropriate production systems

	UN (1971)	Stewart (1972)	Khan (1973)	Dos Santos (1974)	Hvelplund (1974)	Behari (1974)	Brouwer (1975)	Reddy (1975)	Askin (1977)
A. Production factors									
1. labor intensive	x		x	x	x	x		x	x
2. low capital cost	x							x	
2a. per workplace		x		x					x
2b. per unit of output		x							x
2c. per machine		x							
3. low energy costs					x			x	
4. simplicity	x					x	x	x	
4a. in manufacture		x							x
4b. in operation			x		x				x
4c. in maintenance and repair		x	x		x				x
4d. in organization		x							x
5. locally oriented with respect to									
5a. scale of market			x	x	x	x		x	x
5b. available skills and entrepreneurs									
5c. use of raw materials	x	x	x	x	x	x	x	x	
5d. use of energy resources					x		x	x	
B. Process of change aspects									
6. geographically dispersed, rural development		x		x		x	x	x	x
7. ecologically sound					x		x		x
8. commercially viable (short/long term, increasing GNP)	x		x	x	x	x			x
9. fulfilling basic needs (products for low income groups)	x				x			x	x
10. self-help, control over production factors					x				x
11. "organic growth" of production systems					x				x

the literature are presented, together with a number of selected references. The criteria under B imply and set boundary conditions to the criteria given under A. Feature 2 is usually seen as the complement to feature 1. The criteria 2a-2c, as well as 4a-4d, will often be inconsistent, hence "low capital cost" and "simplicity" are without further elucidation void of meaning.[32] Operationalisation of criteria under B often make it impossible to meet one or more of the criteria under A.

The justification of the criteria is based[33] on the one hand on macroeconomic considerations such as rural development, employment, import substitution and national energy policy; and on the other hand on an idea how the given society should be in the future: self-help and local control over all aspects of production systems. In arguing for appropriate systems, it is often forgotten that the real situation, in which these systems are to be applied, is a dual economy, with a rural and a modern sector. From this it follows that the application

32. This is shown in detail e.g. in Stewart (1972). See also section 1.5.
33. Following Jéquier (1975).

of the criteria in processes of change to be induced, is different with respect to the rural and the modern sector. For example, a conclusion might be that scale of production should be increased in the rural sector and decreased in the modern sector.

All criteria will be discussed in more detail in subsequent sections, in particular in chapter 4, where respectively the case for labour-intensive, small-scale, rural-indigenous and capital-intensive industry is stated and evaluated in terms of the appropriate choice of mixture of production systems in a particular economy. Before that, in section 1.6 the problems involved in the choice of production systems will be discussed. It here suffices to say that by far the most basic dilemma's are: employment vs economic growth; and imported technology and machines vs self-reliance.

In this report "appropriate" shall be used in its literal meaning: a production system is appropriate, relative to a given set of "ultimate" value judgements (providing the choice of product and an evaluation of the effect any production system has on its environment), when the then best production system is chosen and put into operation according to expectations - given a correct analysis of the boundary conditions and their possible change. (Note the circularity.) Although this report is basicly concerned with appropriate production systems for developing countries, the notion is applicable to any society. In the sequel many examples of inappropriate production systems will be mentioned. I know of no good examples of an appropriate production system.

1.2.4 Preaching for the good. At the conference in Hyderabad mentioned in 1.2.2 Malhotra warned that 'there is a danger that intermediate technology may be treated as an abstraction like "truth" and modern Jesting Pilate may ask "what is intermediate technology?" and may not wait for an answer'.[34] The same applies to any other adjecti-

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34. He added: 'In some ways, "appropriate technology" or "optimum technology" would seem to be better because the term is self-contained, refers to a particular situation or phase of development and does not depend for its own significance on a reference upward to a high point and downward to a low point.' But I do not think "optimum" or "appropriate" are safer. Maybe they are more sophisticated in hiding value judgements better. Cf. also the quotations of Singh (1975) in note 21.

ves (or capitals) used to express one's concern. It does not matter much whether we call *The Good* by the name of *Engineering* or *Systems Theory*[35] or *AppropriateTechnology*. It all boils down to technology being an abstraction capable of solving any problem: the capitals or adjectives are used to indicate that it should solve the problems as we see them: 'Alternative technology is applicable to the development of the third world because it provides permanent, non-polluting development for local communities of people', as Mendonza (1977) says in, appropriately, the Journal of Speculative Anthropology. Such statements are not statements of fact supported by evidence, as the form suggests (A is applicable to B, because ...), but a conjunction of a formal definition (i e the terms in the definition may or may not refer to existing things) and a value statement (i.e. : that local communities should have ...).

35. See on systems theory note 2. Cf. also the following digression: In his contribution to the first conference on appropriate technology for the UK,Professor M.W. Thring (Sc.D., C.Eng., F.I.Mech.E., F.I.E.E., M.I.Chem.E., F.Inst.P., F.Inst.F., F.R.Ae.S.) wrote: 'So far UK technology has been based on short-term local interests ... The paper will outline the Creative Society described in my books ... in which all these misuses are overcome by having a society based primarily on human creativeness in which Engineering is devoted to serving the ordinary world citizen ... Nevertheless, it is only the Engineer who can see what is possible and hence he has a very great responsibility to educate the Public and the Politicians to the essential long-term worldwide Ethos.' (Thring, 1976.) Now I do not want to raise questions such as: "Did not a lot of human creativeness go into the industrial revolution?", or: "Is not Engineering serving the ordinary world citizen by providing transistor radios?", because Thring probably explains in his books that he means something different. On the contrary, I am interested in the form of the statement, for example the use of capitals. In 1822 Comte wrote: 'A social system in its decline, a new system arrived at maturity and approaching its completion - such is the fundamental character which the general progress of civilisation has assigned to the present epoch ... The existing crisis is manifestly common to the several nations of Western Europe ... The true Organic Doctrine can alone produce the harmony so imperatively demanded by the condition of European civilisation ... the necessity for confiding to Scientific Men the preliminary theoretical labours recognized as indispensable for reorganizing society is solidly based upon ...: (1) scientific men are by the character of their intellectual capacity and cultivation alone competent to execute these works; ... (3) they exclusively possess the moral authority ...' (Fletcher, 1974, pp. 111-134). Apparently nothing very much has changed.

As we shall see in more detail in section 3.1 all important political bodies are in favour of appropriate production systems, but of course this does not mean anything. It blurs in particular the fact that what is appropriate for one group is not appropriate for another group. I think much clarity would ensue if an attempt was made to separate questions of fact and value - although that is never fully possible. As to the values, say: reduce unemployment (even at the cost of economic growth in terms of gross national product as usually measured), I prefer not to call certain values appropriate and other values inappropriate. Appropriate should be restricted to apply to the factual content of relative judgements, i e a judgement as to what means to use to arrive at a certain end. If used that way, I think there is no redundancyin talking about appropriate production systems because it is by no means trivial that one succeeds in selecting the appropriate production system in a given context. The loaded meaning, however, is then gone: it is not necessary to state that one is in favour of appropriate production systems, *that* is trivial. But we can sensibly discuss whether in a particular situation, say: wanting to transport large quantities of agriculture products from the hinterland to the city, hovercraft-vehicles are more appropriate than building roads and bridges.

1.2.5 The denotation of appropriate. Much has been said up till now about the connotation of appropriate, i e which conceptual ideas are part of the concept of appropriateness when applied to production systems. It would be interesting to make a careful study of what production systems have actually been called appropriate and analyse them in terms of the questions mentioned in 1.2.1. One would find, of course, that not one characteristic is universally applicable: similarities crop up and disappear. For example, consider an anaerobic digestor for a farmer in Scotland and for a farmer in India; a distillation unit for an isolated oil-well in Alaska and for a local gin-producer in Nigeria; all four are small-scale and could be appropriate, but for each pair all other characteristics differ vastly. On the other hand consider making a long canal plus irrigation facilities;

there are numerous ways of doing that, appropriately, but it will remain a large-scale project.

The examples in the previous paragraph illustrate the effect of the environment. On the other hand there are the interests of those involved. Somebody concerned with poverty may be in favour of certain, if possible specified, appropriate systems for the development of rural areas. He may find the United States Government in complete agreement with this line of action, but the interest of the latter may be less in poverty than in reducing interest in the factors governing world trade; or their interest may be in the fact that rural development programs decrease the investment in urban export industries that may compete with American industries on the world market, whereas rural development may well increase the export market for the United States.

1.3 Production factors[36]

1.3.1 The production function. A production system, as defined in section 1.1, has inputs and outputs. The output is called a product; examples of products are: cassave roots, dried paddy (rice), palm oil, bread, methane gas, furfural, crude oil, urea, bricks, cement, hydraulic press, cracking unit, plastic containers. The inputs are called the production factors: those (catagories of) things needed to make the product. Traditionally only two production factors were considered in economic theory[37] : capital, C (to buy machines, etc.), and labour, L (to do the work). The production function, $Q=f(C,L)$, gives the output obtained with different quantities of capital and labour. It is clear that the constants in the function will depend on the production techniques that are available.[38] Assuming a simple continuous function,

36. Sen (1960, 1975), Salter (1960), Stewart (1972, 1974).
37. More precise: in macroeconomic considerations there are traditionally three production factors: capital, labour, and nature. However, when it comes to production functions, nature is gone.
38. 'Since technical possibilities and restraints originate in technical knowledge which exists at a number of levels ranging from pure science to applied know-how, there are certain ambiguities in the idea of alternative techniques implied by a given state of knowledge. These ambi-

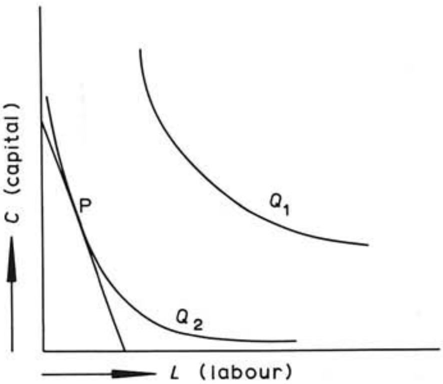

Fig. 1. Production functions for different outputs when production techniques are available for all (C,L) combinations.

we may draw isoquants for constant Q, as illustrated in Fig.1. On Q_1 lie all the (C,L) combinations that give output Q_1. Given[39] certain factor prices for capital, p_C (= amortisation + interest), and labour, p_L (= wage rate), the optimum choice of production technique to obtain a certain output is easily found by finding the point, P, where a line with slope $-p_L/p_C$ is tangential to the production function, Q_2

In practice there will rarely exist a smooth production function, because production techniques are not available for all (C,L) combi-

guities are reflected in the production function concept which could refer either to techniques which have been developed in detail, or to techniques which are feasible in principle but have not been developed because the necessary economic pressures are absent. It is suggested that the latter concept is the most relevant to long-run analysis, although it contains many difficulties.' (Salter, 1960.) The problem of *what* is available shall pop up regularly as we proceed.

39. 'Because technique decisions relate to additions or replacements to the pre-existing capital stock, the appropriate means of measuring capital in the production function is in terms of real investment, and there is no need to consider directly the capital equipment already in existence. The corresponding concept of the price of capital has the sense of capital costs per annum, consisting of amortisation and interest (or normal profits). This is the concept of the price of capital which corresponds to the wage rate as the cost of employing labour, and is consistent with the normal concept of long-run total costs.' (Salter, 1960.) Of course, measurement of capital and labour is not that simple. In the way the production function is defined, the amount of capital and labour relate to output. However, often capital is measured in terms of capital per worker. (I have been informed that Salter, 1960 is now somewhat outdated. I am still looking for a simple, straightforward, unambiquous account of production functions.)

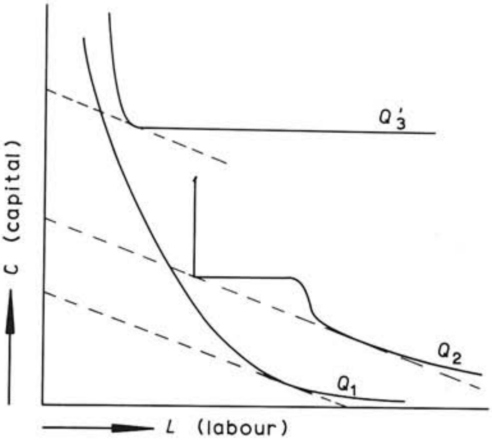

Fig. 2. Production functions for different outputs when, at some scales of production, there is a limited choice of production techniques.

nations. For example, for a particular product the available production techniques could be as illustrated in Fig.2. Assume Q_2 = 100 Q_1 and Q'_3 = 100 Q_2; Q'_3 is a product similar to $Q_2$and Q_1 but it meets more strict specifications. In the case of Q'_3 the relative prices of C and L do not affect the choise of production system;[40] apparently only one such system is available. In the case of Q_2 the situation is similar over a certain p_C / p_L range. If the relative cost of labour drops below a certain level apparently other production techniques become feasible. For a production of Q_1 a smooth curve is given. The figure also illustrates the situation where producing on a large scale, Q'_3, gives a much lower cost per unit of output than small-scale production, Q_1 or Q_2; again over a large range rather insensitive to relative factor prices.

The production function applies to one particular moment. The common theory of production refers to equilibrium - but equilibrium does not exist. Adjustments to changing conditions take long periods of time to work themselves out, particularly when capital equipment is involved. This slow adjustment is accompanied by continuous dis-

40. The use of the term "system" in "production system", as introduced in 1.1.1 is in discord with the kind of uses "system" is put to in economics. I see no solution.

turbance due to improving technical knowledge and changing factor prices.

1.3.2 The variety of production factors. Non-economists would be amazed if they knew what far-reaching theories and policies are based on production being determined by capital and labour costs via the production function as given in the previous subsection.[41] There are clearly six areas that ask for further analysis. Problems with determining factor prices and the concept of technical progress are left for the next two subsections. Here we deal with the homogeneity of capital and labour, other production factors and product and process characteristics.

Homogeneity of capital. Passing over the insurmountable difficulties of measuring capital, it is often assumed that C stands for fixed capital, thus neglecting working capital.[42] Total working capital requirement will be a function of the production technique and more

41. Economists are also aware of this problem: 'how simplistic and often useless is the economist's traditional production-function approach to the topic' (Baer, 1976.), but more articles like that of Gaude (in: Bhalla, 1975) are needed to convince those economists that are not particularly interested in the details of the problem: '... no serious attempt was made to test other assumptions that are more realistic in an underdeveloped setting, such as dependency of the capital-labour ratio on labour productivity through technological change and economies of scale, under-utilization of inputs ... market imperfections, the relation between the level of aggregation and the size of the elasticity of substitution, and the effect of the passage of time ... Moreover, highly aggregate estimates tend to be meaningless because of the large variety of production conditions in the developing setting...' See however note 45. And as to external criticism: 'Central to the whole analysis of neo-classical economics is that it treats individuals, their structure of wants and the choices and substitution resulting therefrom, as the ultimate and independent data of the economic problem. As a result, the chain of causal influences and causations no longer finds its origin in the circumstances and conditions of production as was the case with the classical economists, but now the emphasis shifts away towards final demandand consumption. This has two important consequences: firstly, the market, or the set of interdependent markets which constitute the sphere of exchange, now become virtually identified with the subject matter of economics, beyond which the analysis does not go. Secondly, the distribution of incomes is conceived of as being determined from within the market in the form of a set of derived prices of given factors of production.' (Wuyts, 1974.) Only very recently economists have (again?) become interested in the individual welfare function "behind" the demand and its relation to income distribution and other environmental factors. See for example Kapteyn (1977).

specifically on the time lag between income and expenditures. Often working capital requirements will be higher for labour-intensive techniques.

Homogeneity of labour. Different production techniques require different skills of labour. For example capital-intensive techniques usually require highly qualified egineers. Labour-intensive techniques ask for a different kind of managerialskills. Other aspects include: number of shifts, labour productivity.[43]

Other production factors. Apart from capital and labour there are other inputs in a production system, in particular raw materials and knowledge. Knowledge, being mainly an investment, is usually counted as capital costs. Raw materials, in particular natural resources is an undervalued factor if it comes to factor substitution. Current definitions of technical efficiency have led to a tendency first, to minimise the use of raw materials, and then to minimise costs by choosing the optimal C / L ratio.

Product and process characteristics.[44] By using a production function for one product, one passes over the fact that there is not only a choice of technique available for any given product, but also a choice of product see further 1.6). Secondly, one passes over the fact that any production system contains a number of different operations. Each operation or process involves a different activity. Hence, the overall factor proportions depend on the aggregate of factor proportions at each stage of production.

In enumerating all these neglected factors and disturbances, it is beyond dispute that economists, if asked, would agree that their "two

42. Capital is the stock of resources available to help satisfy future wants; in the context of this report in particular the stock available for production. Fixed capital, then, consists of machinery, equipment, buildings, drainage works and such like. Working capital consists of raw materials, semi-finished goods, stock of product and possibly net claims to third parties.
43. Productivity has a multitude of meanings. One should clearly distinguish the personal efficiency of labour and the output derived from a composite bundle of resources. Labour productivity in terms of output per man is usually assumed to indicate growth and hence becomes synonymous with welfare (identified with income per capita).
44. These aspects have been particularly stressed by Stewart (1972, 1974, 1977).

factors - three goods - no-time" models do not apply to reality. And they will point out that, in principle, more complicated models can easily be developed[45], but that data to test or use these models are just not available or impossible to obtain. However the major point is that decisions are and have to be made and that the present behaviour of planners, advisers, politicians, and others involved in choosing production systems at the national level, suffers from too much belief in science, i e believing in the simple production function and basing policy decisions on such an analysis, whereas common sense - as distinct from economics - is enough to list the factors mentioned in the previous paragraphs.

1.3.3 Factor prices. There are serious problems involved in measuring factor prices.[46] In evaluating the choice of techniques we shall distinquish - given choice of product and output - four different values of C: (a) the choice made by a particular investor, (b) the choise the investor should have made given the information he had and factor prices,(c) the choice that should be made when the investor has maximum information,(d) the choice that should have been made on the basis of non-distorted factor prices.

Most of the problems involved here will be dealt with in 1.6. Here only some terminology will be introduced. The first is that of dual labor markets (Sen, 1975). There is general agreement that in underdeveloped economies wages in different sectors of the economy are different for the same kind of labour, i.e. there are different

45. To differentiate capital there are the so-called portfolio and vintages models. Time series is a well-known object of statistical analysis. However, time series studies usually do not discriminate between vintages of capital, and vintage models usually do not provide simultaneous estimates of changes in labour (Pack, 1974). Tinbergen and others set up production functions taking into account different types of labour and knowledge as production factors, etcetera. In evaluating projects all agencies nowadays make a distiction between unskilled and other labour. (See e.g. Dasgupta (1970) on OECD and UNIDO techniques of project evaluation.)

46. The measurement of capital is notorious. But there are also simple practical problems. For example: 'it is exceedingly difficult to obtain estimates of how much it would cost to produce 1950-vintage equipment at the current time; even in less developed countries with internal capital goods capacity, production of this type is not undertaken.' (Pack, in: Bhalla, 1975, p. 156.)

labour markets. Dualism of labour markets may arise from a number of different causes:

(a) job preferences, such as preference for being one's own master, rather than a 'wage slave';

(b) indivisibilities in labour supply: impossibility to work half-time on a farm and half-time in a factory;

(c) loss of share of family income;

(d) labour legislation and union pressure;

(e) employers' incentives for paying high wages.

It is clear that causes (a) - (c) are quite different from causes (d) - (e) in terms of the actual mass of people ready to work in the high-wage sector.

The second area of terminology is that of cost-benefit analysis. In such an analysis we are concerned with the economy as a whole and on that basis try to evaluate which investment projects should be undertaken, i.e.given limited investible funds which projects should be chosen. The choice can be between infrastructure or industry, between fertilizers and cement, or between one sugar factory or another.[47] In stead of calculating in terms of costs and revenues for a private firm in a cost-benefit analysis the *social benefit* of a project is compared with the *oppertunity costs* or social costs of the project, i.e. the social value foregone when the resources in question are moved away from alternative economic (or other) activities into the specific project.[48] In making such an analysis, prices of various goods may be assumed that are different from the existing prices in the economy concerned; these are called *shadow prices* (and sometimes: accounting prices). In evaluating a project we need cost-benefit or investment criteria by which we can evaluate as to whether the project increases

47. It is common to distinguish three dependent factors in investment decisions: (a) total amount to be invested (as taken from income),(b) distribution among different industries, (c) technical form of each particular investment. See section 2.2.3 on development planning.

48. In practice only a limited number of alternatives is considered, in particular if the economist, evaluating the benefits and costs of a project, is subject to political or other constraints that narrow the range of choice. Cf. 1.6.2.

social welfare. In theory we want a *Pareto improvement*, that is any change after which everyone in society could be better off.[49] But how do we quantify "better off" and if income is relevant then, probably, perceived welfare is not only a function of income but also of income distribution.

An important factor that affects the choice of appropriate factor prices is the elusive notion of efficiency. 'A situation can be described as technically efficient if it is impossible to move to an alternative such that the change yields something for nothing.(...) A situation is economically efficient if no Pareto-superior position is available, i.e. if there is no way of making someone better off without making somebody else worse off.' (Sen, 1975). These are straightforward definitions, but it does not follow that their meaning is clear when applied to real situations. First, there is the problem of the availability of alternative production systems. Secondly, there is the problem that prices for the same input may be different, depending on which production system is chosen and/or where it will be located.[50] Thirdly, the question as to what are inputs and what are outputs may be quite unclear.[51] In general, it is always in some way arbitrary what to count as a separate output and what as a separate input. Finally, as to the Pareto-condition, it is clear that real decisions always imply that some are better of and some are worse off.

49. Definitions vary in the literature. 'The project in question, to be considered as economically feasible, must, that is, be capable of producing an excess of benefits such that everyone in society could, by a costless redistribution of the gains, be made better off.' Mishan (1975, p. xii). The Pareto criterium is the major efficiency criterium in welfare economics. See also section 2.2.3.
50. For example bamboo-made looms in India are cheap. The price of bamboo, however, would rise considerably if the whole textile industry would start using bamboo looms.
51. This brings us to the point that the concept of a production function, although technically irreverent to what is input and what output, as thought of in most of the literature, is biased to a cause-and-effect analysis of reality as distinct from a hanging-together analysis of reality. In other words: it is rather arbitrary what we choose as dependent and what as independent parameters. A generalized theory of production should just list factors, e.g. Boon (1974a) chooses: product characteristics, annual production volume, size of lots or production units, prices of capital and various types of labour, number of work shifts, work allowance, social fringe benefits and implied costs of labour, skill level distribution.

With respect to efficiency and similar terms I shall use the following terminology. A production system is technically possible if it can produce the product needed. A production system is technically efficient if there are no other production systems that produce more output at given amounts of capital and labour. Production systems that are not technically efficient are inferior or obsolete. A production system is economically efficient if - given factor prices - there is no other production system that can produce the same output at lower cost. A production system is economically feasible if it is economically efficient at some reasonable shadow prices. What is reasonable is not defined. A production system that is socially appropriate should be economically feasible.

1.3.4 Technical progress and development. Technical progress is traditionnally associated with (a) savings of labor, (b) savings of raw materials, (c) mechanisation, (d) inventions (Schefold, 1976). In terms of production functions it is associated with a shift of an existing production function, e g from Q_1 at time t_1 to Q_2 at time t_2, where $Q_1 = Q_2$; see Fig. 3. Following Stewart (1974) I shall use the term "technical development" in stead of "technical progress" to cover developments such as that of Q_1' to Q_1''. Three types of development[52] can be distinguished: (a) improvements in the quality of inputs other than capital (e g in work organisation), (b) improvements in machines and operations currently in use, (c) entirely new methods of production. Only developments (a) may generate shifts such as that of Q_1 to Q_2. The other two only affect parts of the production function -

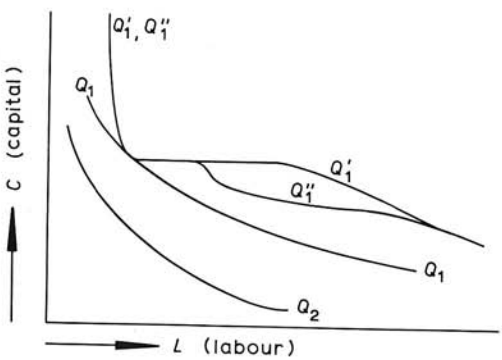

Fig. 3. Production function for the same output at different times, illustrating the effect of technical development.

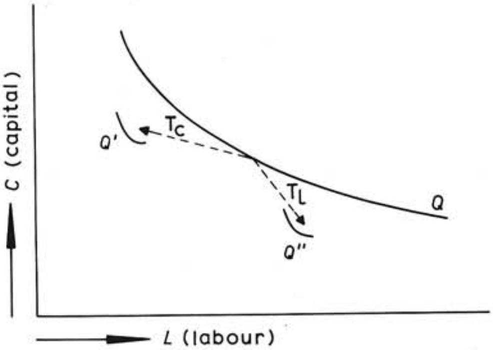

Fig. 4. Change of production function illustrating technical development in a labour-intensive and capital intensive direction respectively.

assuming that it is usually not smooth.

The direction in which technical developments occur is neither arbitrary nor smooth. It will be affected by expectations of changes in factor prices[53] and increase of market size. Historically we see that technical development with respect to a certain product starts at a low-output labour-intensive level. The industrialisation in Western Europe led to large-scale capital-intensive outputs. But other economies show alternative developments: slave economies (e g Egypt) may have large-scale labour-intensive production techniques. This is illu-

52. One may broaden the meaning of technical development even further by defining it as any change in the function $f\colon (C,L) \to Q$, and this will be the one naturally adopted by econometrists and other people trained in mathematics.
53. According to Sen (1975, p. 110); 'little evidence is available showing the influence of factor prices on the development of industrial technology.' (Baer, 1976.)
54. In particular situations there can be technical development along a horizontal line (same capital, less labour), i.e. the given production function shifts to the right in such a way that a production system having coordinates (C_1,L_1) obtains coordinates (C_1,L_2) when adjusted to new circumstances.
55. Hence 'One wonders how far the use of highly mechanized techniques in such underdeveloped economies is due simply to the fact that the details of Western technology reflect the need to save labour, and that this set of detailed designs may be quite inapplicable to economies where labour is cheap. Perhaps underdeveloped countries should use Western knowledge to develop a detailed technology aimed at methods that are modern and technically efficient but not mechanized.' (Salter, 1960, p. 15n.)

strated in Fig. 4. Assume that at one time the production function for, say brickmaking, is Q_1 and smooth over some region. Technical development T_C creates part of $Q' = Q$ by developing capital-intensive techniques. Technical development T_L creates part of $Q'' = Q$ in the labour intensive region.[54] Typically the technical development in the industrialized countries has been towards using less labour (and natural resources) and more capital to produce more and more outputs.[55]

1.4 Economies of scale

1.4.1 General Principles. The term "economies of scale" refers to the fact that the cost of production factors, in particular capital, is usually a function of the scale of production.

Tradionally it is assumed that this empirical fact is best fitted by a power function, i e $C = aQ^n$, in which C is capital, Q is capacity, a is a constant, and n is called the scale factor. Furthermore, everyone knows that large-scale production is cheaper, hence $n<1$ and on logarithmic scales the function should give a straight line, such as the one given in Fig. 5. The empirical relation is assumed to exist for capital costs of single apparatuses, for individual production systems, and for complete industrial branches. Similar functions are assumed to exist for other production factors such as overhead, labour, area, energy, and perhaps raw materials.

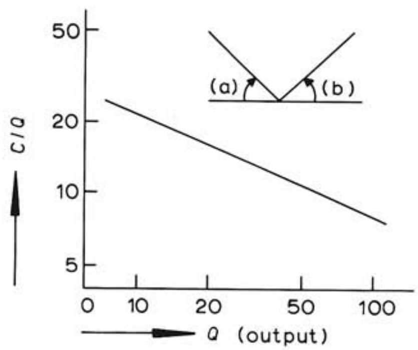

Fig. 5. Illustration of the effect of economies of scale. When there are no economies of scale C/Q is constant. In the inserted figure (a) corresponds to economies of scale and (b) to diseconomies of scale - as "seen" from a given (C,Q) combination.

In the development of the industrialised countries, economies of scale together with technical innovation have been the prime causes for savings in production factors. It is clear that competition on rapidly growing markets is a strong inducement to realisation of economies of scale, while the latter are conducive to the formation of monopolies. Because of the scarcity of some production factors economies of scale also induce changes in products and the processes to make them.

There appears to be a strong bias with respect to the degree and a priori inevitability of economies of scale. For the capital costs of a given apparatus or process, there are physical laws that imply economies of scale. The two most important are probably (a) because of area/volume ratio and the laws about strength of materials, larger objects (like vessels) need relatively less material to construct than small ones, and (b) the laws governing the heat economy of a burner or reactor are a function of volume. But, for other aspects of economies (or diseconomies) of scale, there exist only speculative explanations.

As we shall see in more detail in section 2.3.3 the basic problem of developing countries in this connection is their market size. For example, according to Kuzmin (1977) at present the minimum scale of a copper refinery to be competitive on the world market is 100.000 ton/yr. With copper consumption levels of about 50.000 in Africa and 60.000 in Asia (excl. Japan) it is clear that copper producing countries have virtually no possibility for vertical integration (i e: engaging not only in mining but also in refining their copper), unless they can influence prices in such a way that they can attract financial sources to set up large-scale refineries at the copper mine.

1.4.2 Mechanical engineering and overheads.[56] The effect of economies of scale in mechanical production systems, is also relevant to

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56. This section is based mainly on UNIDO (1969c). Some data on economies of scale are given there, but they do not seem to be very reliable. In this publication the conclusion seems to be that the only solution for small markets is the use of computers in planning and big jumps in order to start with a minimum critical mass. In fact, it appears that the large multinational engineering and electronic firms have little problems in establishing viable small capacity production systems in developing countries. Cf. van den Brink and Menkveld (1976). Another aspect that seems to be undervalued in UNIDO (1969c) is the effect of small innovations on production costs.

chemical production systems, because chemical apparatuses are part of the output of the engineering industry. 'In the engineering sector, economies of scale appear in three separate ways: in regard to the length of the production run (seriality); in regard to the scale of over-all output of a production shop or department; and in regard to the sharing of organizational resources (management, engineering, design, research and development and marketing facilities) between a number of processes and products.'[57]

The length of the production run, i.e. the total output of a single product, will be influenced in a particular economy by the variety of products and standardization. The economies of scale associated with the length of a production run derive mainly from two factors: the time and expense involved in starting (or switching) the operation of a product run (developing costs, retooling, etc.) and the increase in efficiency during the length of the run, due to learning processes, and small innovations.

The economies of scale associated with total output arise from: (a) economies of scale in the price of machinery needed, and (b) the possibility to coordinate and utilise machine capacity and labour better. Minimum scales of production are affected by the minimum size of equipment on the market, in particular of the more special equipment: A heavy press may be needed to make a particular product and it must be purchased, even if only a small fraction of its annual capacity is utilized. Above a certain size economies of scale disappear because production lines are simply duplicated.

Economies of scale arising from sharing organisational resources[58] arise because of indivisibility of certain specialised skills such as design and marketing, while larger marketing or design sections tend to become more proficient, due to learning processes and in-service training possibilities. A special aspect in the category of sharing

57. UNIDO (1969c). Pratten (1971, pp. 10-14) lists the following general sources of economies of scale: indivisibilities (items of auxiliarly equipment, senior management, preparation of advertisements, R&D, ...), economies of increased dimensions of capital equipment, specialization, massed resources (e.g. fewer spare parts necessary when using several identical machines), learning effect, economies through control of markets, use of inferior techniques.

resources by different product lines is the linkage that exists between products and processes (or machines): Products require the joint utilisation of several processes, while processing facilities can turn out a great variety of products. Furthermore engineering products are used again as inputs for other mechanical production systems. Hence, the manufacture of each product affects the production cost of very many other products.

1.4.3 Chemical industry. The chemical industry is said to be particularly sensitive to economies of scale. The reasons for that are not very clear. The chemical industry is certainly capital-intensive, at least per workplace.[59] But from that it does not follow, as is sometimes suggested, that there should be strong economies of scale. Only for the production of bulk chemicals, form the capital costs a large part of product costs and the relation between the weight of an apparatus (and hence the price) and its capacity may thus induce strong economies of scale. In general, however, the causes for economies of scale, if any, are not well understood (and hardly studied).

In table 2 some data for n are given for apparatuses performing some unit operation[60] and in table 3 for whole production systems.[61] If these data are reliable,[62] then the value of n is typically in the range 0.6 - 0.8.[63] The minimum capacities given in table 3 are usually

58. 'The advantage of large-scale production over small-scale production in unit costs is derived in part from purely technological economies of scale and in part from the facilities of economic "overheads", such as research, bulk buying and selling, cheaper and easier credit facilities, advertising, standardization of products, specialized facilities for tooling and repairs, organization of specialized maintenance staff, facilities for specialists' advice and so forth. The latter facilities - or economic overheads - can be provided to small production units by surrounding them with appropriate agencies - private, cooperative or statutory - which can take over the functions of economic overheads and perform them as common services to small units. Important among these agencies are state-sponsored industrial finance corporations, industrial extension services, sale and purchase cooperatives, industrial research institutions, corporations supplying machines on a hire-purchase basis, firms specializing in tooling, repairs and the like, credit cooperatives, and so on.' (UNIDO, 1964.)
59. The scale factor for labour cost is reported to be in the range 0.2-0.4 (UNIDO, 1969a; Pratten, 1971), but this hardly affects cost per unit of output in the chemical industry. However, non-productive labour costs are increasing sreadily.

TABLE 2. Scale factors for various chemical apparatuses.

equipment	n
tanks	0.5 - 0.8
reactors	0.2 - 0.6
evaporators	0.3 - 0.7
crystallization	0.5 - 0.7
filtration	0.5 - 0.8
centrifuges	0.7 - 1.3
dryers	0.3 - 0.7
solid handling	0.2 - 0.7
distillation	0.53

TABLE 3. Scale factors for a number of chemical plants.

product	n	capacity range (1000 tons/yr)	n for LDCs (?)
sulphuric acid	0.62 - 1	10 - 500	≫ 1
calcium oxide	0.56	5 - 100	
titanium oxide	0.62	4 - 30	
carbon black	0.2 - 0.7	4 - 500	0.7
calcium carbide	0.5 - 0.8	5 - 60	
ammonia	0.58 - 0.81	18 - 500	1
urea	0.59 - 0.71	16 - 500	1
styrene	0.53 - 0.9	5 - 300	
oxygen	0.47 - 0.64	60 - 150	
complete refinery	0.8 ?		

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60. Figures as given for n are mentioned in many places in the literature. I have not been able to find reports of actual data that support these values of n, indicating over what range of capacity n has been calculated. Woodier and Woolcock (1965) discussed the .6 rule for plants and conclude that *within the range of sizes normally built* there is no doubt that exponents are between 0.4 and 0.8. Guthrie (1970) gives values of n for more specific groups of apparatuses: different types of dryers, centrifuges, etc. In general, the more sophisticated types have higher values of n. (Added in proof:) Pikulik and Diaz give guidelines for 'cost estimating for major process equipment' in Chemical Engineering of Oct. 10, 1977. The power law is not referred to; only some of the cost-capacityrelations are straight on logarithmic scales; only marginal information is given on how the cost data were gathered. I would expect that the article is not very useful for, say, an Indian designer who can order most of the apparatus he needs in India.

61. Data as quoted by Moore (1959), Robertson (1965), UNIDO (1959, 1965, 1969a), Gallagher (1970), Guthrie (1970), Ruskamp (1974, personal communication). Moore reports data published as early as 1952 by

determined by the commercial availability of factory equipment. As we shall see in section 2.4 during the time that import substitution policies prevailed,many chemical plants have been installed in developing countries of a scale that appeared to be too small to be economically feasible, and often at the same time too large for the market available.

For chemical production systems more than others,the main cause for economies of scale is the available technology and machinery. The development of the chemical industry in industrialised countries has been of a vastly growing scale of production. Virtually no research and development has been carried out to design feasible production

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Chilton and Leontief and criticizes the reliability of the data, because they are often based on two or three observations, while factors such as the location of the plant and the product grade have not been taken into consideration. I am not aware of any recent study on this subject, or any study at all that gives a statistical analysis on the question as to whether the values of n reported differ significantly from 1. Pratten (1971) has made a detailed study of almost all industrial branches in Britain, with respect to economies of scale. His study includes the following products: sulphuric acid, ethylene, refineries, dyes, synthetic fibres, beer, cement, soap. He does not find the exponent n representative enough to use as the sole parameter for economies of scale. He always find economies of scale, but his study is biased so much in finding the 'optimum maximum' scale, relying on the opinions of the experts engaged in building new - hence larger - plants that the results are not very useful in the present context. Gallagher (1970) provides data "from his own files" without giving further details. Guthrie (Chem. Eng., June, 1970) presents data for 54 chemical processes: '... not many comprehensive, consistently-plotted sets of such charts can be found in the literature. To fill this gap, I have tried to pull together a great deal of operating- and capital-cost data from personal files as well as secondary sources ...' Guthrie corrects his data for time (inflation) and location. At this laboratory, in 1974, Mr Ruskamp collected data as reported in chemical engineering journals over the same period as Guthrie did and later. He finds a much greater scatter than Guthrie does, and in particular for plants installed in LDCs there seems to be no relation at all between capacity and investment. If one forces a power function on the data for LDCs more often than not $n \geqslant 1$ (cf table 3). Compared with the problems in choosing the appropriate price adjustments to compare different times and places, and the strong influence of the site-location, the choice of process (for the same product) does not seem to be important. The point here is not that n for the plants considered by these authors and chemical engineers in general is in fact larger than 1. The question is twofold (a) how far from 1, and, more important (b) if the incentive for machine manufacturers were to be to sell in a market for small and smaller apparatus how would n then develop.

systems, smaller than those in fashion. Although there is a definite scale-dependence of heat economy and surface area/volume effects, it is to be expected that if processes are adapted to a smaller scale n will be much more nearer to 1 than is generally assumed. In chapter 5 an account will be given of scaling-down experience in the chemical industry.

1.4.4 Diseconomies of scale. Increases in cost per unit of output as scale increases may occur for the following reasons:[64]

(a) Rising factor prices. Examples of such factor limitations are: labour supply in an area (skilled or unskilled), space available, limited supply of water or input material (which may be obtained from another near-by production system), no capital available.

62. 'The .6 rule when applied to complete plants runs into difficulties not encountered on individual equipment. Some expenditures are relatively fixed for large ranges of capacity, for example the utilities system in the plant, the "overhead" facilities, plant transportation, instruments, etc. Complicated industrial machinery does not necessarily exhibit the same relationships between area (cost) and volume (capacity) as do simple structures like tanks and columns. Furthermore, for both items of equipment and complete plants, the gradations between sizes are not necessarily small. Indivisibilities in size are a real factor in some cases; an illustration from the crude pipeline industry will be discussed later. In spite of these obvious limitations, estimates of the value of b [i.e. n] have been made for a number of industries or products. These estimates are apt to be best for industries: (1) which are continuous-process rather than batch-operation; (2) which are capital-intensive; and (3) in which a homogeneous, standardized product is produced, so that problems of product-mix do not intrude to muddy the definition of capacity.' (Moore, 1959.)

63. Giral (1975) relates a number of case studies from which it appears that for conventional chemical production systems installed in Latin America n is nearer to 0.4 than 0.6. On the other hand the same production systems adapted to local needs and environment gave n > 0.75. For example:

product	scale range (ton/yr)	n	$n_{adapted}$
intermediate organic	100 - 4000	0.4	0.75
extrusion plastic sheets	250 - 2500	0.5	0.8
granulation of fertilizer	2 - 150	0.4	0.85
unknown high quality ceramics		0.55	0.95

It could be argued that these data are not very reliable (and probably they *are* biased), but they are quoted in the economic literature, e.g. Hellinger and Hellinger (1975). Hence chemical engineers should be in a hurry to provide better data.

64. Summarized from Pratten (1971).

(b) Increasing physical forces (stresses, strains, friction) may limit increasing the size of apparatus or equipment ($n \rightarrow 1$).

(c) Effectiveness of management. Although a large firm may employ more specialized skills the increase in length of the management chain may severly effect the efficiency of operation.

As is clear from the way these diseconomies of scale are formulated, they apply to the range large scale - very large scale. This is typical for almost everything that has been written on economies of scale. Because the economists or engineers writing about it think of a vastly growing, highly developed industry , they are interested in the scale where designing an even larger plant or firm may become disadvantagous, so that R & D can be directed to passing that point; in stead of analyzing how the situation is, and could be, at the other end of the scale.

1.4.5 Assumptions underlying $n = 0.6$. I shall pursue the argument in the last paragraph by listing a number of factors that influence the belief[65] in the overall importance of having to choose large-scale production:

(a) The rule of thumb is that $n = 0.6$. This figure, however, is not based on physical considerations but on the prices that have in fact to be paid.[66]

(b) The belief refers to capital-intensive production systems. By choosing other more labour-intensive techniques, if they exist or can

65. I think, it is reasonable to call it a belief, because the empirical evidence for $n = 0.6$ is shaky; no serious attempt has been made to adapt chemical production systems to smaller scales; while the subject is approached by statements such as: "Uns ist es in diesem Zusammenhang unerklärlich, wie man in den Entwicklungsländern den Problemen des "scaling down", d.h. der Auslegung kleinerer Kapazitätsgrössen, mehr Aufmerksamkeit schenken soll. Damit würden aus rein wirtschaftlichen Gesichtspunkten die vergleichweise hohen Produktionskosten noch weiter steign.' (Stankiewicz, 1968.) That the economically efficient scale is a function of the environment as given (or made) is illustrated in an overwhelming way by the recent development in the USA with respect to refineries. Since 1974 about 40 "pygmy plants" (100 - 30,000 bbl/day) have come into operation, whereas plans for about ten large-scale plants were abandoned. It is expected that for the next eight years or so no large-scale plants will come into operation. Reasons for this change include government prices and taxes regulations and environmental protection aspects.

be developed, the economies of scale can be expected to be much lower.[67]

(c) The possible scales of production are dependent on machines and processes commercially available.

(d) Economies of scale are different for (i) different product specifications, (ii) different unit operations, and (iii) differences in the physical state of the materials in the various stages of the process.

(e) Markets may be distorted, favouring large-scale production units.[68]

Apart from (a), all these factors imply that it is not so much the impossibility of feasible production below the "optimal" scale, but more the fact that each technical development is likely to be related to a particular production level. That is, given the technology at a parti-

66. 'Statistical evidence bearing on the existence of economies of scale in industry is, for the most part, sketchy and incomplete, although the logic of the economic and technical origins of such economies has been extensively developed. Reasons for this lack of statistical evidence are not hard to find; detailed cost studies of different sizes of plants are a sine qua non for analysis of the problem, yet such studies are difficult to obtain.' (Moore, 1959.) See further notes 60 and 61.

67. This applies in particular to metalworking industries. 'Much has been said about economies of scale to support capital-intensive production. There is no question that quantity production lowers unit cost in the industrialized countries. One finds, however, that this is not necessarily true in the low labor-cost economies. There is a direct correlation between economies of scale and the capital-labor ratio between alternate production methods. Thus, economies of scale tend to become less effective as more labor-intensive methods are employed in production. The economic incentives and constraints that dictate capital-intensive production are generally not present in the low-labor cost economies, yet these methods are unquestionably applied in the developing regions. This practice has led to the erroneous conclusion that manufacture of modern-sector products is usually uneconomic in the developing regions because the markets are small. In reality, production of most modern-sector products can be quite economical in the developing countries if the product designs and the production processes are appropriately tailored to suit the local factor endownments. There are many interesting examples in South and Southeast Asia which support this theory. The small-scale production of power tillers, Jeepneys and the McCormick-type threshers in The Philippines, low-lift water pumps in Vietnam, air-cooled gasoline engines and power tillers in Thailand, diesel engines and machine tools in India and Pakistan are good examples which indicate that economies of scale are not as significant as advocated by many established manufacturers from the developed countries in their arguments against local production in the developing countries.' (Khan, 1973.) See further section 3.2.

68. 'But suppose we follow our Tanzanian economist on his trip to ask advice to his western colleagues. He now poses the question why it is that Tanzania cannot produce iron, or steel or some other industrial products. Nine times out of ten the answer will be that Tanzania's mar-

cular moment there is exactly one choice, similarly to the one choice available for capital-intensity as discussed in section 1.3. The question is not whether there exist economies of scale for a *given* product and a *given* set of techniques to make it; the question is, what is the relation between scale on the one hand and factor or technique substitution on the other. But on the latter point virtually no research has been carried out.[69]

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ket is too limited for these commodities in order to allow the country to profit from economies of scale. Indeed, one would argue, mass production allows for the use of methods of production which are considerably cheaper than producing for a limited market. By now, our economist might feel puzzled = check-mate on two accounts diametrically opposed to one another. Indeed, if mass production allows for methods of production to be put in use that are considerably cheaper than methods of production appropriate to smaller markets, would not one expect prices of the industrial products to follow with the ever widening markets for these products? And if prices would be rising due to the high income elasticity and to the fact that methods of production would involve more inputs (i.e. rising supply function), why not produce these commodities ourselves at lower costs?' (Wuyts, 1974.)

69. 'Today, it is important to decide how much of the undoubted economies of scale are due to the organization of the economy and therefore of technological development, and how much to genuine physical facts which must be present in any organizational system.' (Stewart, 1977, p. 65.) 'Why economies of scale should favor capital intensive processes is unclear: it just seems to be a fact of technological nature for the particular processes investigated. To what extent can it be generalized?' (White, 1976.)
As yet there exists not one detailed and reliable feasibility study on the economies and other aspects of scale of any production system. For example, in numerous countries sugar factories of a large or intermediate scale have recently been built or are being built, but all feasibility studies seem to have an a priori bias to either large or intermediate scale, and so called comparative studies tend to present rather abstract models, which - to obtain any meaning - depend heavily on non-existent or unreliable data. In general one would expect that appropriate production systems for developing countries have to be less subject to economies of scale, because - contrary to the situation in industrialized countries - fewer products with extreme or extremely common product characteristics have to be produced.
It is quite possible that intermediate scale production is in theory the best economic option. For example, Kilby (1965) studied the Nigerian bread industry and found that a bakery having a daily flour consumption of about 1300 kg enjoys slight economies over smaller and larger units. At a larger scale distribution costs rise sharply. But it does not follow that the economical appropriate scale is realized. Kaplinsky (1976, personal communication) found that 70 per cent of the bread in Kenya is made by large firms, although according to any macroeconomic criteria the traditional intermediate scale using wooden ovens is better. Extra-economic factors such as the price policy of the large firms destroy small firms.

1.4.6 Economy of de-scale.[70] The economy of de-scale, a most neglected subject, is based on the observation that if one reduces the scale of a production system, there are a number of discontinuous jumps in capital costs. That is, the function $Q \rightarrow C/Q$ is not logaritmic but has a form as given by curve (b) in Fig. 6. Strictly speaking curve (b) is a compilation of a large number of different production systems which all have their own range of possible application and, usually a much narrower range within which they are the most efficient set of techniques.[71]

Examples of such discontinuous jumps in capital costs are: (a) below a certain level, computer and other automatic controls become unnecessary, (b) at still lower levels various types of mechanisation become redundant (given certain factor prices). When output falls, the complexity of design and construction is lessened, and hence, also the skills required; in particularly the costs paid out in foreign exchange fall. Material costs reduce because apparatuses become simpler, e g,by

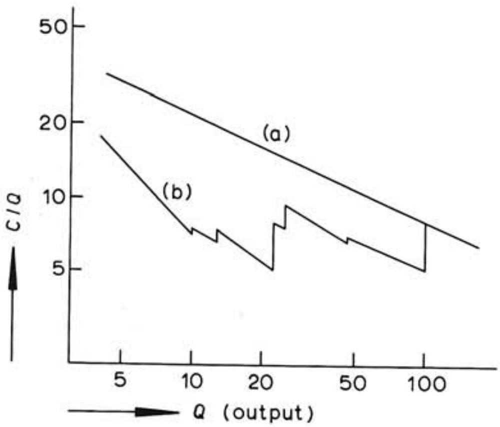

Fig. 6. Illustration of the possible effect of economies of de-scale. Curve (a) assumes one type of production system for the whole range of outputs. Curve (b) is an assembly of parts of production functions for systems that each have their own limited range of outputs.

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70. Following Onyemelukwe (1974, pp. 41-49): 'This then comprises another kind of scale-oriented economy, which we call economy of de-scale. Thus while advanced countries at the upper limits of market potential can operate at those levels by pushing the economy of scale, those at the lower limits can equally invest in the same activities by pushing the economies of de-scale and using these to suit their own factor endowment.
71. Cf also Figs 2 and 3 and accompanying text.

going from continuous to batch operation, or working at lower temperatures and pressures. Civil works progressively reduce with diminishing scales of output and common services become simpler and cheaper.

In opposition to the arguments in the previous paragraph it is usually stated that together with de-scale, variation in product quality strongly increases, and in the end,production of a particular product becomes completely impossible. This argument, however, passes over the choice of product and of raw materials. As will be argued in more detail in section 1.6.4 it is not the quality of the mass product, but the end use of the product that counts. One should also keep in mind that it is only yesterday that mass-produced goods were considered inferior, and the virtues of quality of small batch production are still known. It is known that advertising does affect sales positively, but it could well be that de-scaled production is better capable to cater for personal or local market interests. The point that I want to get across is not that small-scale is better, but that it is an open question. Any combination of needs and boundary conditions has its own appropriate production system. To counter the bias to the other side, it is necessary to stress those situations where descale is appropriate.

1.5 Types of production systems

1.5.0 Introduction. In this section a number of rough definitions of various types of production systems are given. Subsequently the following aspects are discussed: capital: capital-intensity, degree of mechanization, simplicity; scale: small, medium, large; labour-intensity: skilled, unskilled, entrepreneurial/managerial; environment: urban, rural, modern, traditional; source of technology: foreign, indigenous. Whether particular types of production systems are appropriate to development is left to chapters 2 and 3.

1.5.1 Capital. The adjective capital-intensive is often used to describe a typical aspect of "modern" industry. In 1.3 the problems of measuring capital, C, have already been mentioned. First, there is the question relative to what C is high. There are at least three sensible possibilities to define capital intensity: in terms of the ratio C/L (capital vs labour), in terms of C/Q (per unit of output), and relative to the value added. Secondly, the units of C, L and Q have to be chosen; and thirdly, the actual measurement has to be made, which always involves the problems of aggregation. It is generally agreed that working capital should be included, when defining a production system as capital-intensive; on the other hand the ratio of fixed to working capital is an important economic characteristic of the production system. Another problem is that the capital intensities of two projects will depend on price variations in production factors, while market prices have to be changed into shadow prices.

'The case for a lower "capital intensity" is sometimes confused with that for a lower degree of "mechanization", but the two concepts are really rather different. The degree of mechanization is concerned with the ratio of the value of the stock of machinery to the number of labourers who can be employed *at a point of time when the machinery is in operation*. Or else it can be seen as the ratio of the former to the output flow *at a point of time when in operation*. In contrast, capital-intensity is concerned with the ratio of capital stock to the total amount of labour time *over a given period* (...), taking into account the points of time when the machinery is in operation as well as those when it is not. Alternatively capital intensity can be seen as the ratio of the former to the output produced *over a given period*.' (Sen, 1975, p. 47.) For example: A handloom has a lower degree of mechanization than the large-scale automated looms, but if it is operated only a small number of days in the year, its capital-intensity may be quite high.

Other possible differences include: working capital that is often higher for relatively less mechanized techniques; the investment in education and training that depends very much on the type and degree of mechanization but without a clear correlation with capital intensity.

The absolute amount of capital intensity seems to be related to the type of product and types of operations. Textile industries are traditionally less capital-intensive than petrochemical industries. Auxiliary operations such as handling, packaging, (un)loading are traditionally less capital-intensive than the operations involving a change in the form or state of the material.

In the way that technology has developed, there seems to be a positive correlation between capital intensity and the simplicity of operation of the production system, while there is a negative correlation with the simplicity of making the capital goods needed. Simplicity of operation may increase the organizational or administrative complexity.

1.5.2 Scale. As with all concepts subject to measurement, scale is a relative concept. What is small-scale in Brazil may be quite large in The Gambia. A small-scale car factory may be quite large compared to a large-scale bread factory. I shall first discuss the concept of small-scale industries.

Small-scale or medium-scale production systems come under different names and have different denotations. Japan calls them "small enterprizes" and includes service activities such as retail marketing and laundry establishments. India calls them "small industries" and includes only the manufacturing industries. Japan and India do not include handicraft and cottage industries, but many other Asian and African countries do. Following Vepa (1971) three sectors can be distinguished:

(a) modern small industry for urban centers;

(b) agro-based industries;

(c) rural artisans and handicrafts.

Although this might be a useful distinction for development policies I think too many characteristics coincide. In the sequel I shall use the range family, small-, medium-[72], large to indicate relative scale of production for any product. As we shall see below, on all scales there is the possibility of modern vs traditional methods of production and of production in rural or urban areas. Family-, and small-scale in rural areas corresponds roughly to the terms cottage and village indus-

72. Medium-scale corresponds roughly to what is called "intermediate" scale in the literature when "intermediate" only refers to scale. I prefer, however, the more neutral "medium". In the literature a number of definitions of "intermediate" are given in terms of investment per working place, e.g. Schumacher (1974), Hoda (1974) and Marsden (1969). These are all most disputable.

tries as used in the literature.

As will be explained more fully in 1.6 the need for production is the need to fulfill certain needs and not to make a product of exact specifications. Hence, when considering the scale of a production system we consider a whole range of products that fulfill the need specified in some way or other (leaving open the question as to which do best). For example, if the need is for fertilizer, we may include under family-scale: using manure directly; under small-scale: anaerobic processing of manure; and under medium and large-scale: artificial fertilizers. To give some provisional idea of the possible relation of scale to other production factors, in table 4 three scales of producing sweetening agents are given. The table only serves as an illustration, i.e. the data should not be taken too seriously.

The smaller scales of production correlate - for given needs - with lower absolute cost to start a business and are often relatively labour intensive (but not necessarily so). In particular it should be stressed that small-scale production systems can be very capital-intensive. For example, it may sound interesting to make board plates from agricultural wastes; but the type of presses needed to make any type of board give the system a very high *C/L* ratio.

Small-scale production methods are usually simpler or easier with respect to initial capital needed, entrepreneurial and other skills, and the dependence on the physical environment. Table 4, however, shows also very clearly that if the goal is to have a large output the organizational problems involved in establishing one sugar factory employing 1000 people are quite different and in many respects easier than somehow getting 10,000 gur production units off the ground, involving 100,000 people.

TABLE 4. Comparison of the production of the sweetening agents: gur, khandarsi, and (crystal) sugar.

	gur	khandarsi	sugar
investment, 10^6 Dfl	20	20	20
number of units	10,000	50	1
employment, 10^3	100	10	1
production, 10^3 ton	150-250	30-60	10-30
% sucrose in product	75-85	95	98.3-99.9

1.5.3 Labour. Usually the term labour-intensive is used in the literature as the opposite of capital-intensive. This, of course, follows from the fact that the traditional production function considers only two factors. For the same reason as mentioned in 1.3.2 it may be misleading to identify labour-intensive with capital-saving.

Finally there are those production factors that can hardly be classified as labour or capital (in a microanalysis), in particular natural resources. It is easy to give examples in which two production systems have the same labour intensity, while one is capital-intensive and resources-saving and the other, the other way round. A similar argument can be given if slightly different products fulfill the same need.

Secondly, there is the choice of measurement scale. If C/L is used, then of course labour-intensive and capital-intensive are opposite by definition. But C/Q and L/Q may suit one's purposes better and draw attention to the fact that low C/L production systems often give higher C/Q ratios than high C/L systems.

Thirdly, there is again the aggregation problem. Is working capital included or not? As to labour, interest is often in the intensity of unskilled labour, in particular on a macroeconomic level.[73] Furthermore, intricate ways of finding appropriate shadow prices for different types of labour may influence the outcome considerably.

Although straightforward, it should be stressed that there is no necessary connection between scale and labour intensity. Product characteristics may have some bearing on scale and/or labour intensity, while as was remarked in 1.3.4, technical development in industrialized countries has favoured large-scale *and* capital-intensive. But for the same product, from a dam to leather goods, scale and labour intensity can be varied independently.

1.5.4 Urban and rural. The meaning of "urban" and "rural" does not pose particular problems. In developing countries urban and rural areas appear to behave as rather independent economies: they have e.g. dif-

73. Cf. e.g. the definition of Morawetz (1974, p. 498): 'Measuring factor usage in terms of services, and valuing these services at shadow prices, an industry or technique is labour-intensive if its ratio of unskilled labour costs to total factor costs is high relative to that of other industries or techniques.'

ferent labour and product markets.

Of importance is, that urban and rural are only descriptive demographic terms. In particular, it is not necessarily the case that rural industry is small-scale or not capital-intensive or not modern. Plantations are large-scale and can have a traditional or a modern, a labour-intensive or a capital-intensive structure. A hydropower station is situated in a rural area (although not many people will call it a rural industry). Think also of mining or wood production. In a rather different category is the modern small-scale industry: in Japan and China small modern electronic industries are situated in rural areas. These examples do not imply that one finds more modern large-scale industries in the rural areas, because that is not the case. But it should be carefully analyzed to what extend this is a necessary correlation, e.g. due to markets and services, or due to boundary conditions that could be changed, e.g. indirect higher government subsidies to urban areas (possibly due to transfer of income from rural to urban areas by state agencies dealing with agricultural products).

1.5.5 Foreign-indigenous. Use of foreign technology means that knowledge and/or machines and/or techniques have to be imported - once or continuously - in order to produce something. Two rather different aspects have to be distinguished: First,use of foreign technology implies dependence. Secondly, using foreign technology may result in a production system not adapted to needs and environment. If one has to buy machines, which one cannot make oneself, dependence can never be removed. However, adaptation to needs and environment is certainly possible in principle.

Although in exceptional cases imported foreign knowledge and machines may fit completely in a given set of needs and circumstances[74], it is more probable that when the process of adaptation is taken seriously, one starts to generate new technology. If this can be pursued so far that any significant dependence disappears we shall say that indigenous technology is available.

Alternatively (and a priori perhaps better), we can start from the traditional production systems in a given society. When knowledge of these systems is available (as distinct from pure craftmanship to operate them) this is also, by definition indigenous technology, which can be developed further.

1.6 Choice of product and production system

1.6.1 Transfer, generation and adaptation. Ideally a choice of production system involves relating technical feasibility to economic considerations, institutional requisites and cultural conditions. Two levels of choice should be distinguished:[75]

(a) the choice of production system by an entrepreneur having or seeing a market, or a state agency responsible for producing goods to fulfill certain needs: a microeconomic decision in a given context;

(b) the choice of production systems at the national level, where macroeconomic and welfare considerations prevail in trying to affect decisions under (a), by changing the context and social-cost benefit analysis of large investments in which the government takes part.

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74. By an exceptional case I mean such things as the example of an iron smelter in a primitive village in Japan by Nash (1954): 'In Shimane there existed until recently an iron smelter. This smelter, possessed of enough modern technology to work four to five thousand pounds of iron at a single smelting, was organized along traditional lines, embedded in a community which, by most sociological scales, is ranked "folk" or primitive. The more important characteristics of the factory organization were (1) the persistence of a traditional method of iron smelting, the origin of which is associated with a myth; (2) the existence of a special dependency relationship between workmen and owners; (3) an hereditary occupational system; (4) a strong esprit de corps among workmen based on faith in a guardian deity. The community itself was socially closed and culturally isolated from the neighboring farm villages. Within the village, relationships were kinlike and village endogamy was approached. Industrially, the employer and worker were lined by social relationships and social usages which were the very antithesis of analogous economic relationships in communities like Middletown or Yankee City.'

75. This distinction may be distorted by the influence of international agencies who provide money or knowledge, only if a particular production system is chosen: Then in fact no choice exists. The criteria for choice (cf. 1.2.3) are of course different for a) and b). In the first case emphasis will be on aspects such as economizing on scarce factors and accomodating to levels of skills and industrial organization. In the second case the emphasis can be on maximizing employment or economic growth. (This point is expanded in chapters 2 and 3.)

In this section we concentrate on (a). Assuming that it is a given fact that a certain product has to be produced in a certain quantity, the following lines of action are available:[76]

(a) import the final product;

(b) select, acquire, and transfer[77] a production system from elsewhere to make the product, using: (i) imported intermediate products, (ii) imported raw materials, (iii) indigenous raw materials;

(c) identify a suitable production system elsewhere and adapt it for the purpose and environment given, e.g. by (i) updating an old or obsolete system, or (ii) down-scaling of a system in use elsewhere;

(d) identify and improve indigenous traditional production systems, usually by scaling-up and upgrading;

(e) generate new production techniques that suit the purpose and environment.

For large-scale modern production systems transfer is a complicated business, because setting up such systems is inherently complicated. Apart from the feasibility studies and market surveys prior to investment, the aspects of transfer are best summarized by looking at the institutional or legal mechanisms for transfer (Turner, 1977):

a) Concessions or licence to use patented formulae, designs, models, procedures or specific pieces of technical knowledge;

b) Contracts for the supply of equipment and corresponding operating instructions; and

76. In the literature on appropriate technology, the distinction is usually made between (a) use and improve traditional production systems, (b) import and adapt suitable production systems, and (c) invent new ones. See for example Ntim (1974), Hoda (1974), Reddy (1975), Gadgil (1964). I use "adapt" only for foreign technology. Traditional or indigeneous production systems are not "adapted" but "improved". "Generation" may start from either foreign or indigeneous knowledge or both.

77. We should carefully distinguish between the transfer of technology (i.e. the transfer of knowledge) and the transfer of production systems. In the literature, where this distinction is not made, probably the best definition is: 'When scientific or technological information generated for, and used in one context is re-evaluated and/or implemented in a different context, the process is called technology transfer.' (Bar-Zakay, 1974.) In that case it includes the technology transfer proper that is from one production context to another, e.g. helicopter technology from air force to toy industry. It also includes the transfer of Volkswagen manufacturing and marketing from Germany to Brazil, what we call transfer of production systems.

c) Contracts for the supply of technical services associated with the provision of technical knowledge concerning the management and operation of the production facilities and concerning marketing the product.[78]

The main characteristic of such production systems is that they are almost inadaptable; instead the environment, including cultural, institutional and even economic aspects of it, has to be adapted to prevent the production system becoming inappropriate.[79]

1.6.2 Factors impeding the appropriate choice. The factors most often discussed in the literature are, for governments: bargaining power with respect to multinationals and contractors, as well as personal interests and prejudices;for entrepreneurs: factor price distortions, lack of information and various forms of non-rational behaviour. However, there is little hard empirical evidence available to support the positions taken.

The major obstacles to transfer are a communication gap and a suitability gap (Streeten, 1972). A suitability gap, because the production techniques offered were designed to suit developed country factor endowments, including the types of labour available.[80] The communication gap results because of: existence of monopolies, restriction on markets set by seller,[81] high costs of transfer,and in general lack of power of the government of the developing country.[82]

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78. 'Contracts and licences are combined in different ways, ranging from the most *packaged* arrangements to the most *unpackaged* ones, depending on how many groups or individuals are separately contracting with the technology recipient. In the most packaged case the recipient contracts with only one contractor to supply the whole technological ensemble needed for what is then a turnkey project. At the other extreme the recipient contracts with one supplier for each element of technical knowledge and might even be supplying some itself.' (Turner, 1977.)
79. ... although more adaptable than is in fact assumed by the people selling and operating the production systems. Rice (1958) describes how the Calico textile factory in Ahmedabed (India) underwent various technical changes in adopting itself to prevailing social organization. See for a more extreme example note 74. Studies on the anthropological effects of modern industries in traditional societies deal mainly with the textile industry in India. See e.g. Nash (1954), Christopher (1974).
80. Examples are given in sections 2.3 and 2.4. See also 3.2.
81. For example a licensor may be obliged to sell all his output to a sales company wholly owned by the supplying company. Very often there are restrictions on export markets.

By far the most discussed factor impeding appropriate choice is factor price distortions. Traditionally it is assumed that the price of labour is too high and of capital too low.[83] It is said that labour is artificially expensive due to minimum wage legislation, various non-cash fringe benefits (social security), restrictions on firing, union bargaining success, guilty aversion to paying lower. On the other hand, capital and imported goods are subsidized by regimes of cheap interest

82. 'Control in the transfer of technology can only be understood in relation to conflict and as a means to settling conflict in the interests of the dominant party. As such the substance and exercise of this control should be distinguished from its formal appearance (e.g. equity shares). Although the exercise of control can be learned - as in the case of the use of more sophisticated bargaining strategies - it more importantly reflects the underlying power of the respective parties. Thus power ultimately stems from the ability to mobilise the technical and financial resources necessary for capital accumulation.' (Kaplinsky, 1974b.) The reasons for the bargaining position vis-à-vis the seller is succinctly summarized by Turner (1977): '1. The supplier has thorough knowledge of the object of the transaction and the buyer does not; 2. The buyer does not have enough knowledge about alternative sources of technology and transfer conditions; 3. The supplier knows how to sell technology as that is his trade while the recipient does not know how to buy it since he usually purchases the technology for a single project; 4. The supplier is protected by industrial property legislation and practices whereas the buyer usually does not have any legal structure to guide him, let alone protect him; 5. As a rule the marginal cost of the technology is low and decreasing for the supplier, whereas it is high and risky for the buyer; 6. The supplier often has close and helpful connections with the financial agents; 7. The supplier is often assisted by his own government and by other "political" externalities; 8. The supplier often has large marketing resources in the form of publicity, public relations, prestigious trademarks, etc., with which to impress the buyer; 9. The technology transaction is usually welcomed by local industrialization policies.' Cf. also, (a) Thomas (1974) who stresses the absence of an S&T basis as the major cause, and (b) the special issue on conflict and bargaining of *World Development*, 1976, Nr. 3. The weak position of the receiving partner has long been neglected by official agencies. It is doubtful whether lip service such as UNIDO's helps much. ('The existing scene of transfer of technology to the developing world reveals by and large little or no bargaining strength on the part of the developing countries, lack of capabilities of their enterprises to select technology and negotiate equitable, still less favourable, terms and conditions, and equally to adapt or even absorb the technology, and a lack of national capabilities to channel and regulate the flow of technology to national advantage.' (UNIDO, 1977d.))

83. See Morawetz (1974), Pack (1976). The idea that limited technical substitutability and factor market imperfections are major deterrents to the introduction of labor-intensive techniques, was already expressed by Eckhaus (1955). Empirical studies, however, were not made until the 1970s. Of course, anecdotal evidence is abundant.

rate, overvalued exchange rate, low tariffs on imported goods, tax incentives for investment. These distortions in the prices of labour, capital and imports encourage substituting capital (and imports) for labour.

Factor price distortions may also directly result from an imperfect market, in particular monopolies or trusts. For example large-scale producers may sell their products for varying prices on local markets, depending on the presence or absence of competitors. Also they may set the prices of their raw materials artificially high to rule out competitors. Nobody doubts that factor prices in developing countries diverge widely from social opportunity costs. The question is how relevant this is to the choice of techniques.[84]

In particular in the smaller scale industry lack of, or incomplete information about, available alternatives plays an important role. This applies in particular if the best choice were to be second hand equipment or machinery that has been in use in Western countries 50 years ago, but is now out of production. Of course access to relevant information also plays an important role in the bargaining context mentioned above. A very special aspect of lack of information is that, usually, entrepreneurs or governments can only choose from among the options with which engineers present them. 'Engineers trained according to developed

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84. It *is* relevant in the context of general economic policy. Because of high domestic profitability due to the degree of protection, and the imperfection of domestic competition, projects may be evaluated as having an internal rate of return of over 25%, while adding little value in terms of gains in real welfare, measured in world prices. See further sections 2.3 and 2.4.
85. Pickett et al (1974); also: 'In the present context the basic trouble with engineers is that they are professionally driven by what Schumpeter once called "the half-artistic joy in technically perfecting the productive apparatus". Give an engineer a machine and his instinct is to improve it; give him a plant and his instinct is to automate it. From his point of view this is perfectly understandable, even laudable. The engineer's interest is in technical efficiency - in extracting the maximum amount of sucrose from a given input of sugarcane; and from this standpoint machines are often more reliable than men.' Similar conclusions follow from the empirical studies of Cooper et al (1975).
86. 'For example, in choosing tubewell technology in what was then East Pakistan, the modern technology was considered to be more risky by the local farmers, since it was installed by outsiders, difficult to operate and repair, less adaptable to local conditions, and required a large initial investment. For the donating agency, the modern technology was

country curricula are asked to design the plant. They produce blueprints for a limited number of alternatives, each of which is a variant on current "best-practice" techniques.The alternatives are submitted to economic (perhaps DCF) scrutiny, the most attractive chosen, and another capital-intensive, technologically inappropriate plant is established.'[85]

The behaviour of the engineers above is non-rational in the strictly economic sense. This attitude is closely related to the attractions of politicians to "shiny" projects. We enter here the area of prejudices: "the latest will be the best", "our dignity conflicts with using second hand machinery." Of course what is rational or irrational depends on one's point of view. Apart from those situations where personal interests are involved (financial or political), two different view points can both be economically rational when embedded in two different real or conceptual social frameworks.[86]

From the above it is clear that the factors that impede making the appropriate choice is not simply a techno-economical problem but is embedded in national as well as international development policies. In the next chapters policies that might impede the situation will be discussed on various places. A second point is that the details may be different for developing countries, but the structure of the problem is the same, always when a choice of production system is to be made.

1.6.3 Empirical evidence. As mentioned in note 83 empirical research on the factors influencing the choice of techniques did not really start until the 1970s, except in the textile industry, and gained some

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considered to be less risky, since it was installed by a foreign contractor, with whom a legal contract could safely be entered, and involved concentrated, easily supervisable drilling locations (Thomas, 1974).' (Morawetz, 1974.) Also consider the case of "self-reliance" vs. "government aid": Villagers decide to dig canals themselves relying on local labour and materials. Assume they extend the working day to do the work. What happens is then that (i) labour-intensive techniques are used, (ii) real wages go down, (iii) probably there is small rise in consumption because they eat more, (iv) there is a genuine surplus. If the same project would have to be carried out by the central government they might consider sending a group of workers to the village with equipment: it is possible that only a capital-intensive technique is viable in such a situation. 'This example clearly shows that the choice of techniques available to a country is as much dependent on the social organisation of the country as it is on technical data.' (Wuyts, 1974.)

momentum only very recently, although the discussion on factor substitution is as old as the concept of the production function.[87] Representative of the type of research and the resulting conclusions, is a recent investigation by Pack (1976) of the Kenyan manufacturing industry, concentrating on the substitution of labour for capital. He concluded that '(1) there is considerable variation in feasible, efficient production methods, particularly in peripheral operations; (2) substantial gains in labour productivity without capital deepening occur'. The industries studied included paints, soap and cement. In these and other cases where the processing operation involves mixing and/or heating, the possibilities of *L/C* substitution appear to be limited, since reversion to older methods is likely to reduce quality and uniformity. Exceptions to this rule were found, for example using simple bin-drying in stead of the capital-intensive method of drying soap noodles in metal towers by hot flowing air, but this hardly affects the labour needed. Most employment occurs in the auxiliary activities anyway, e.g. filling operations of any sort generate considerable employment.

Contrary to what is usually expected all industries visited did not use the most modern methods, because these were not considered the most economical. Almost all plants began production with a large proportion of used machinery or had bought older models when these were still available. Cans were filled by hand and hand labelled. Fork-lift trucks

87. '... the question of production factor substitution has long been, and for some economists still is, a controversial one. The reason for this controversy is that economists have, until recently, done very little microresearch in the factor substitution question.' (Boon, 1974a, p.1.) Therefore nothing significant can be said as yet, as to the variation in factor substitution possibilities for different sectors. A clear example of the case where macroeconomic decisions are hampered by lack of microeconomical data.
88. Reviews of the empirical evidence have been given by Morawetz (1974), Baer (1976) and White (1976). White discusses 'six kinds of evidence: (1) econometric investigations of the elasticity of substitution between labor and capital; (2) engineering or process analysis of substitution possibilities; (3) anecdotal evidence on substitution; (4) evidence concerning big firms versus small firms; (5) evidence on the use of used machinery; and (6) evidence concerning multinational corporations.' He concludes regarding (1) that these studies 'give some support for the position that efficient labor-intensive alternatives exist', but conceptual and econometric problems make that 'believers in fixed proportions are unlikely to be convinced'. And concerning (2): 'In all,

TABLE 5. Empirical research on the choice of production systems.

author, year	subject
Boon, 1956-	metal/wood working, earth moving
Bhalla, 1964, 1965	textile, grain milling
Hewavitharana, 1970	sugar, coir, textile
Pack, 1972, 1974 [98]	textile, grain milling, paints, soap
Picket et al[99], 1974-	sugar, footwear, brewing, ...
Baron, 1975	sugar
Stewart, 1975	cement blocks
Cooper et al, 1975	can manufacture, jute processing

were only used in 10% of the firms where there were heavy drums (size being stipulated by export specifications) or lack of floor space.

In Table 5 the major empirical studies on factor substitution are given.[88] As can be seen the first studies were concerned with the textile industry in India and the studies of Boon on metalworking. At present there are three large producers of studies: those of the *David Livingstone Institute for Development Studies* at the University of Strathclyde, financed by the U.K.-government; the *International Labour Organization* who commissions individual researchers; and the *Institute of Development Studies* of the University of Sussex.

The studies on sugar mentioned in table 5 will be discussed in chapter 5; there are no other studies on chemical industries. Hence care should be taken in applying the following list of conclusions to chemical production systems.[89] Conclusions as to the existence of efficient labour-intensive techniques include:

(a) Peripheral or ancillary activities (materials receiving and handling, packaging, and storing) offer a much greater scope for varying factor proportions than material processing.[90]

(b) The scope for factor substitution is less, the more the product

the engineering and process analysis studies do provide powerful demonstrations of the feasibility of labor-intensive methods and are probably more convincing than the econometric studies of the previous section, but there are still the difficult questions of scale, quality, and skill substitution.'

89. For a number of production systems no detailed studies on factor substitution exist but it is clear from indirect evidence that a large range of factor substitution possibilities exist. Amonst these: processing of palm oil (see e.g. Kilby, 1969), bread (Kilby, 1965; Kaplinsky, to be published), brick making, natural dyes.

has been specified;[91] less neutral: capital-intensive methods are necessary to ensure high quality.

(c) At higher inputs there seems to be less scope for factor substitution. Small firms are definitely more labour-intensive and less efficient than large firms; it is however unclear whether they work inefficiently on a shadow-pricing basis.

(d) Used machinery is more labour-intensive, and appears very often to be used where it is economically efficient.[92]

(e) The question as to whether foreign firms are more labour-intensive than indigenous firms is unsettled, but they seem to manage the problem of managerial skills necessary for labour-intensive production better.[93]

(f) In the case of detailed product specification and some processing industries, in fact only one (capital-intensive) production system is available, although in general, there are always a large number of

90. Although this point seems trivial upon consideration, it is often forgotten when it is stated that the process industry is by definition capital-intensive. Costs of transport, handling and storage of raw materials and products may be considerable. A distinction should be made between solids and bulk handling on the one hand, and liquids and gases on the other.
91. Product quality may also dictate the use of more mechanized materials handling. This applies in particular to mixing (cement blocks, sugar cane) and handling of products like fruit.
92. On second hand equipment see contribution of Cooper and Kaplinsky, and of Pack in Bhalla (1975). Disadvantages of second hand equipment are high installation costs and higher risks and uncertainties; the latter point tends to be forgotten in superficial considerations. Opinions differ as to whether there is a serious spare parts and maintenance problem.
93. See discussion by White (1976) and recent publications of Pack (1976), Agarwal (1976), Solomon and Forsyth (1977), Morley and Smith (1977).
94. This is what follows from recent studies. Rosen (1958) describes that in the years 1937-55 rising real costs of labour stimulated the introduction of labor-saving techniques in the cement, paper, cotton, textile, steel, and sugar industries in and around Bombay. Also: 'In none of the project reports prepared by visiting experts (except in a report on textiles) that we have investigated has there been an attempt to compare the proposed technique with alternatives, in terms of capital requirements and employment. The report on sugar, for example, gave the technical details of several methods of production but did not discuss the employment aspect since the experts (as they themselves stated) were not requested to direct their attention to it.' (Hewavitharana, 1971.)

alternative techniques potentially available. For various reasons the labour-intensive technique may not be chosen despite lower costs at prevailing factor prices.

The first three, or four, conclusions contain what one would expect. What the empirical studies have brought out rather conclusively, and what is not according to a priori expectations, is as follows.Choice,at least potential choice, between many viable production systems is much larger than generally assumed; and secondly, factor prices do not seem to play a significant role in the process of decision making.[94] In empirical studies the following have been found to be the major determinants in affecting the choice of the production technique by entrepreneurs:[95]

(a) size of the market and scale of operation; larger scale/market: more capital-intensive;[96]

(b) quality of input or output;[97]

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95. Baer (1976) interviewed 20 Brazilian firms and got on average: quality of product, market size, cost of financing, and labour costs as the first four determinants of choice of techniques. Boon (1974a) interviewed 168 managers of enterprises in Mexico. Annual production volume was most often mentioned as the major consideration in choosing, but cost of labour also occurred often. The interest rate or costs of expensive machines was sedom mentioned. Morley and Smith (1977) interviewed 35 firms in Brazil and found that 'In the process industries it seems clear that economies of scale and technical considerations dominate technique choice.' The interviewing technique is, of course, not one of the most precise measurement techniques.
96. See Stewart (1975), Boon (1974b, 1975). From an interview of 35 foreign firms in Brazil Morley and Smith found (as quoted by Baer, 1975): 'With remarkable regularity, scale emerged as the overwhelming determinant of machine choice and labour use. Low labour costs in Brazil and/or the prospect of much higher machine costs were seen as having a small effect on factor proportions in the great majority of cases. Multinationals use more, sometimes three or four times more, labour per unit of output in Brazil than in their home country, but they say this is primarily a result of their smaller scale operations in Brazil.'
97. For example: input of low grade ore (Della Valle, 1975); quality of cement blocks for high buildings (Stewart, 1975) and tin manufacturing for export of tinned fruits (Cooper et al, 1975).
98. Until now only results on sugar and footwear (Picket et al, 1974; Forsyth, 1977) and preliminary results on brewing (Cleghorn and Keddy, 1977) have been published. See also note 341.
99. These studies are basicly econometric as distinct from process analysis studies. The empirically determined points of the production function in Pack (1974) are stochastically scattered over an C-L rectangle.

(c) price of principal input in relation to that of capital, e.g. sugar cane;

(d) time effects, such as length of season; firms in a hurry to enter the market;

(e) skilled labour supplies (on this point the evidence is conflicting).[100]

1.6.4 Choice of product.[101] For a long time economists have missed the point that technical development does not only involve development of techniques, but also development of products. However, a brief look at the industrial development in the last 100 years shows that the development of new products (nylon, colour television) has been at least as important as process development. It is mainly due to the publications of Stewart that the importance of the choice of products starts to be recognized by economists as a more fundamental choice than that of the techniques used to make *that* particular chosen product.

Product development may take the form of changes in the quality of existing products and the development of new products. Both types of development in western industry have tended to the situation that product properties are so finely specified that only one production system exists to make it. New or improved products are developed and then marketed by large industries, who more or less by definition then operate on a quasi-monopolistic market. Their only problem is whether or not there is any demand on that market, hence advertising is needed. Because the end product is highly specialized and produced - given factor prices in industrialized countries - by capital-intensive techniques, this affects all previous production stages *and* the availability of al-

100. References for (c) and (d): Baron (1975); for (d): Baer (1976); for (e): Bhalla (1975).
101. Mainly based on Stewart (1972, 1974.)
102. The same phenomena affects international trade. The same meat product from Tanzania sent to a European quality control agency is positively marked when sent by a Tanzanian subsidiary of a large English firm, and negatively when sent by an "unknown" Tanzanian firm. (Lwakabamba and Ndaalio, personal communication.)
103. Multinationals such as Unilever claim that as a matter of course, their products are adapted otherwise they would not sell them: Examples given include washing powder in rigid bars adjusted to the prevailing hand-working methods, and the plastic containers for margarine that, apparently, were first developed for use in the Congo.

ternative production techniques. For example, if consumers demand drip dry, colour fast, synthetic shirts, instead of cotton shirts, firstly shirtmaking techniques are bound to be capital-intensive, and secondly the feasible range of production methods at the stage of spinning and weaving (and sometimes even cotton growing) is severely limited.

This leads us to the important distinction that products may be classified (a) according to their physical attributes, (b) according to the need they fulfill. Any group of commodities fulfilling the same need may be distinguished according to (i) physical attributes, (ii) the efficiency with which they fulfill the specified need, (iii) the extent to which they fulfill other needs. We should start a cost-benefit analysis not by asking: what techniques are available to make bricks (meaning in fact "bricks of standard and homogeneous strength, size and appearance") or shoes(meaning "the type of things the person making the analysis has on his feet on Sundays"), but we should ask: what products and techniques are available to fulfill the need of shelter or footwear. We might discover then that bricks designed to support the Empire State Building are certainly excessively strong for a single storey accomodation, and that footwear includes sandals cut from discarded automobile tyres, leather sandals made from locally tanned hides, stamped rubber and canvas shoes made from imported materials in partly mechanized small-scale workshops, as well as mass produced factory shoes. It may also draw our attention to alternative raw materials: mud or bamboo in stead of concrete and corrugated iron, the first two giving better shelter in terms of heat comfort in tropical areas.

Introducing a new product may have various negative effects. It may displace an older product even though the new product is less optimal in fulfilling needs. Needs as observed in a society are mainly dependent on advertising and income distribution. Helped by advertising the consumer chooses an image more than a product. Consumer surveys show that consumers prefer the less healthy and over-refined white sugar and the highly perfumed, less functional toilet soap used by 9 out of 10 filmstars.[102] That product adaptation to local needs/markets is possible has been proved, but does not occur very often.[103]

1.6.5 Adaptation and generation.[76] The distinction between adaptation and generation is not a simple one. Generally adaptation refers more to production systems, and generation to working things out from firstprinciples. Together, however, they have to be clearly distinguished from transfer, because they may well be in conflict when choosing a policy. If transfer is made very easy this inhibits local development of technology and production systems. If,at the other extreme, transfer is made impossible one could argue - using the experience in China as an example - that local entrepreneurs are forced to be inventive.

In the appropriate technology movement two schools can be distinguished:[104] (a) those advocating the dissemination of information on "all" existing production systems, assuming that an appropriate choice from these needs very little extra adaptation, and (b) those advocating

104. This distinction is made by Bhalla (1976). A good example of the first group is to be found with Bos (1976): 'The following types of policies seem to be of particular relevance: - the choice of technology should be based on careful analysis of the merits and demerits of available alternatives and the use of correct methodologies, in particular of social project evaluation. The application of such evaluation methods should be stimulated; - price, fiscal, financial and exchange rate policies should contribute to correcting distorted domestic factor and product prices; - more systematic information about available alternative technologies should be collected, analyzed and evaluated; - information about alternative technologies should be easily accessible and disseminated along efficient and proper channels to potential interested parties; - through information, training and demonstration centres at the international, national and local levels the possible technologies should be shown and the beneficial effects of choosing the appropriate technology should be enlightened.' See for example Agarwal et al (1975) for a very detailed set of policy proposals based on these premises. I have not yet found a detailed explanation of the second view. See however section 3.4 on indigenous production systems.

105. 'It is far from clear that the effort is warranted by a cost-benefit calculus. Resources devoted to developing new techniques would, if successful, yield a prototype machine only after a number of years; the actual beginning of substantial production of this new textile equipment would take still longer ... thus potential employment gains, if any, would accrue only a number of years later.' (Pack, 1975.)

106. The adaptation does not only include the adaptation to macrofactors such as labour intensity, but also to microaspects of the design and organization of the production systems. A good example of the latter is the area covered by ergonomics (Corlett, 1968; Singleton and Whitfield, 1968.)

R&D on "new", usually labour-intensive production systems.

The explicit choice for generation is the long-term approach. The assumption is that one will benefit from having a better lot of choices in the long run. On a short term basis it is not realistic to expect anything very much.[105] As we shall see in chapter 4 there is often a too simple belief in solving all problems by establishing an "Appropriate Technology Institute".

Institutes with this name can of course also work on adaptation of existing techniques. In section 3.3 I shall describe in some detail what factors should be considered in the appropriate transfer and adaptation of technology and techniques needed. The following aspects can be kept in mind:[106] adaptation to local raw materials and intermediate compounds, labour and management skills, markets and tastes, climatic condition, scale, degree of mechanization, saving on scarce factors other than capital (water, energy, ...).

2. THE OLD LOOK

2.1 Developing developing countries[110]

2.1.0 Warning. This section is not intended to be a well balanced discussion of development economics. Its function is to introduce some terminology. Subsections 2.1.1 and 2.1.3 are strictly definitional. Subsections 2.1.2 and 2.1.4 contain what struck me most in reading summaries of review articles on development theory.

2.1.1 The meaning of development. "Development" originally had a rather neutral meaning.[111] It usually referred to the evolutionary process of social change due to the change in technological environment: 'techniques *are developed* as knowledge increases, and to take advantage of them calls for new forms of social organization'. It came to have a narrower, but also more loaded, meaning when, at the end of the second world war, in the U.K. a Ministry of Overseas Development was esta-

110. I try, as far as it is possible, to stay out of the discussion on development aid as distinct from development planning and the economic dependence. It should be noted that development aid to LDCs amounts to only 10% of their income from exports, while net income from overseas investment is not more than 2% of the income from exports. Furthermore 'Foreign aid may not do much for its supposed beneficiaries, and often contributes to their suffering and hardship. But it does demonstrably benefit influential and articulate sectional interests in the West. These include the staffs of international agencies and of government departments; bored, power- and money-hungry academics; the churches, which increasingly look upon themselves as secular welfare agencies; and exporters who benefit from sheltered markets.' (Bauer, 1974.)

111. First paragraph follows Mair (1975). In 1970 when still the term "developing" was in use the term "least developed" was introduced (UN, 1970a) and this is still a technical term in UN papers referring to the poorest countries or areas. A definition for the least developed or poorest countries currently in use is: income per head smaller than US $ 100, analphabetism larger than 80%, and industry contributing less than 10% to the national income.

blished. At that time "aid" was given to "underdeveloped" countries, "underdeveloped" being an euphemism for "poor". Later "underdeveloped" was replaced by "developing". When the large international organizations came into the field officialdom seemed to accept "less developed" and the abbreviation "LDCs" is now a name without meaning.

I think "less developed" is the term to be preferred on technical grounds. It indicates that there is no underdevelopment without development.[112] Even better would be to use the term "less developed, dependent" to indicate that some measure of development may be low, due either to physical or other "inherent" boundary conditions, or, even more so, due to the interaction of the less developed system with a more highly developed system.[113]

For almost everybody "development" means "economic development". National income per capita is the conventional criterion of economic development. For comparison one uses either the level or the rate of growth per capita income. Problems of measuring this parameter on one scale (e.g. US $) include: defectiveness of available statistics,

112. The use of the term underdeveloped implies that, in principle, a fuller use of domestic resources (human and natural) and external economic opportunities is possible. Included in this,of course,could be that such fuller use and opportunities are not possible due to constraints set by industrialized countries. "Underdeveloped" would seem quite appropriate if the developed countries would always be called overdeveloped countries

113. For example: 'Underdevelopment, no less than development itself, is the product but also part of the motive power of capitalism. Capitalist development everywhere has been a fundamentally contradictory development based on exploitation and resulting simultaneously in development and underdevelopment. Additionally, the growth and expansion of European mercantilism of the 16th century led to the development of a single, integrated, capitalist system of world-wide scope. Associated ever since the very beginning with the growth of powerful states, the expansion of mercantilism-capitalism led to the development of a metropole and, related to it through ties of commerce and force, of a periphery. Variously related to each other through colonialism, free-trade, imperialism, and "neo-colonialism" the metropole exploited the periphery in such a way and extent that the metropole became what we now call underdeveloped. ... All serious study of the problems of development of underdeveloped areas and all serious intent to formulate policy for the elimination of underdevelopment and for the promotion of development must take into account, nay must begin with, this fundamental historical and structural cause of underdevelopment in capitalism.' (Frank, 1975, pp. 95-96.)

choice of exchange rate, noncash components of real incomes. Conceptually the problems are even greater: National income per capita says nothing about income distribution or any characteristics of economic development such as per capita consumption, standard of living among the great mass of people, type of market, degree of industrialization, etc. Further one should distinguish between stage of development relative to some external standard (i.e.: some value system) and the difference in development between rich and poor countries. This leads to two rather different objectives for favouring development in LDCs: improving material standards in LDCs per se and reducing international tensions. In both cases aggregated measures of economic development will not do, because the dispersion of development affects the subjective experience of well being (be it as a person or as a country).

In most recent years the use of the term "development" seems to have become fully subjective (or personal): "development" stills refers to a process of change, but it has come to mean "change in the direction that the person or institution using the term thinks desirable".

In defining what a LDC is, economists have been more inventive in proposing various criteria.[114] For example, Meier and Baldwin (1957) have succeeded in giving 34 criteria to characterize underdevelopment covering parameters for primary production, population pressures, underdeveloped natural resources, capital deficiencies and aspects of foreign trade. Social scientists, ergonomists and similar non-economists interested in development have provided many suggestions of non-economic parameters of development.[115] But it is clear that conceptual and measurement problems increase progressively in the following list of "development parameters": daily newspaper circulation, gross nation-

114. A strong argument against the use of "develop" or derivative forms is that 'It diverts attention from the much more meaningful ways of characterizing and classifying countries on the basis of their common cultural, social and historical elements - all of which have major implications for the nature of their societies in the future.' (Geiger, 1967, as quoted by Lippert, 1968.)

115. See for example Lippert (1968), Adelman and Morris (1972). In measurement problems one should always distinguish operational precision (Is the number given for daily newspaper circulation correct?) and conceptual precision (To what extent is this measure an indicator of, say, political participation or educational level.) All interesting concepts are, whenever measurable, only measurable on multidimensional scales.

al product per capita, nonagricultural and industrial employment, analphabetism, life expectancy, deaths from domestic group violence, poverty, social mobility, effectiveness of financial institutions, personal welfare functions, political participation.

Because of measurement problems, the measures used in policy decisions are still very simple, GNP ruling the way, occasionally joined by the degree of industrialization and percentage of analphabetism.

Closely related to development is industrialization[116] and in this report I often use the term "industrialized countries" referring to the rich countries.[117] Industrialization can perhaps be regarded as the application of technology to the task of raising the productivity of resources.

2.1.2 Development models.[118] Growth economics assumes the existence of a fully developed economy, and applies growth equations like that of Harrod-Domar: the growth in total output is equal to the savings ratio divided by the capital-output ratio, i.e. if 16% of total output is saved and four units of capital are required to produce an additional unit of output the growth in total output is 4%. In a developing country most of the assumptions underlying this model are not valid: fixed capital-output ratio, sufficient supply of entrepreneurs, ideal market (appropriately reflecting relative scarcities of products and factors of production), efficient allocation of available savings among alternative investment possibilities. The development theories that developed in reaction to this most orthodox view can be grouped as follows:[119]

116. 'Entwicklungsländer für die chemische Industrie sind wirtschaftlich entwicklungsfähige Gebiete, die vorwiegend landwirtschaftliche Erzeugnisse oder mineralische Rohstoffe einschliesslich Erdöl und Erdgas produzieren. Der Industrialisierungsgrad dort ist gering; chemische Erzeugnisse werden noch nicht oder erst in sehr beschränktem Umfange produziert und konsumiert. Ihre Pro-Kopf-Produktion an chemischen Erzeugnissen übersteigt nicht $ 30 im Jahr.' (Stankiewicz, 1968.)
117. For the sake of simplicity, I assume that the OPEC countries do not exist. Often "industrialized countries" or "developed countries" only refers to OECD members.
118. This section is based upon the reviews of Myint (1976), Bertholet (1975), Onyemelukwe (1974), and others.
119. Of course there are 1001 possibilities of giving an ordered account of the development theories since 1945 in one page. According to most commentators both the traditional, neo-classical, neo-mercantilistic, na-

(a) Missing-component approach. These theories regard the shortage of some strategic input, such as the supply of savings, foreign exchange, or technical skills (education), as the main cause of underdevelopment.[120] If the missing component is supplied by external aid the rest follows by multiplication.

(b) Surplus resources. These theories emphasize the surplus resources (natural, human) that should be used to promote economic development.[121] A problem in starting a development on surplus labour is that not enough subsistence capital is available.

(c) Big push.[122] These theories stress the fact that underdeveloped countries are held down by a series of interlocking vicious circles. The strongest argument for these theories is the smallness in the size of the domestic market. This prevents taking advantage of economics of scale and the economies generated by a complementary group of industries. But it is likely that any big push-balanced growth programme is too complicated to be ever implemented successfully.

(d) Deliberate unbalancing. This approach agrees with the analysis under (c) but gives as a solution that limited capital resources should be directed to three areas of imbalance: social overhead (infrastruc-

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tional-populistic, ...,and the neo-marxist, "dependencia", ... schools were forced to change their views fundamentally from 1970 onwards, because the facts wandered too far away from their theories. Apart from very awkward situations such as countries with low GNP (say Britain) giving aid to countries with high GNP (say Kuwait), it appeared that many LDCs were doing quite well on traditional scales of measuring development, apart from those scales measuring gaps.

120. Against this approach it can be argued that education adds to subjective discontent because of educated unemployment; that foreign exchange preservation leads, inter alia to import substitution and protected markets with consequences as given in section 2.3.3.
121. Basicly this is Ricardo's idea that (1837, p. 122) 'Unter einem System vollkommener Handelsfreiheit widmet ein jedes Land natürlich sein Kapital und seine Arbeit denjenigen Geschäften, welche für dasselbe am erspriesslichsten sind. Diese Verfolgung des eigenen Vorteils steht in wunderbarem Zusammenhange mit dem allgemeinen Wohle der Gesamtheit.' and denies all dependence theories.
122. Rosenstein, Nelson, Nurske and others give various reasons why a big push only can be successful. There is the problem of indivisibilities (cf. economies of scale): minimum in social overhead, demand, and savings. And there is the problem of packaging: for one entrepreneur to start, the risk is too great. Singer and others made the simple calculation that a big push is simply impossible, so that it is irrelevant whether the theory is true or not.

ture), directly productive activities and the industries at the end of the production line (such as assembling).

However, all these approaches are still based on the assumption that to start development one needs capital. Although, there is nobody who states that capital has nothing to do with development there are a number of theories that place the emphasis differently. As far as I can see, three interrelated categories of alternative starting points can be distinguished:

(i) the emphasis on the dependence of underdevelopment and development leading to the analysis of world trade, and in the end, imperialism theories;

(ii) the emphasis on agriculture and use of the abundant resources, leading to small-scale and rural production systems needing less capital, both absolute and of a foreign nature;

(iii) the emphasis on institutional change to favour appropriate choice of products and production systems leading to income redistribution.

After a definitional digression in 2.1.3 I shall rephrase these aspects in more detail in 2.1.4.

2.1.3 Poverty and unemployment. If just for a while, we rely on the World Bank, it appears that already in terms of average annual income one could be pessimistic. The World Bank expects that over the period 1970-1980 the average income in the industrialized countries will rise from \$ 900 to \$ 4000; in the least developed countries it will rise from \$ 105 to \$ 108 (that is about one bottle of coca-cola for each year). On top of that comes, as McNamara said in his address to the Board of Governors in 1972, that 'increases in the national income - as essential as they are - will not benefit the poor unless they reach the poor.' Because over the past years all development policies have been reformulated in such a way that they now set out to solve the poverty problem[123] - in economic terms: unemployment -, I shall summarize some of the definitional problems:[124]

If one intends to engage in an employment policy[125] three different aspects of employment, should be considered: the income, the production, and the recognition aspect. Secondly it should be realized that wage labour, as a major form of work, is of recent origin. In most developing countries the vast majority of the labour force works outside the wage system. Either the proportion of unpaid family workers is high, in countries such as Thailand and Greece or the proportion of self-employed workers is very high - Ghana is a typical example. It is only in North America, Western Europe and some countries in South America that the percentage of employees in the economically active population comes above 70%.

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123. Another way to put this is that emphasis has changed from pure economic growth to growth plus distribution. There is some dispute in the literature as to whether the conceptual separation of growth and distribution is due to shortcomings of traditional welfare economics or other factors. I think Lal's (1976) conclusions give the right perspective: 'The current concern with distributional issues amongst the international agencies and American development economists marks more their acknowledgment of their past neglect of what a number of Third World governments and many development economists have for a long time recognized to be a major area of concern, rather than any "new" insight into the development process.'

124. Following Sen (1975): 'Essentially, the concept of employment has to be related to some notion of the "value" of the work ... employment cannot be defined in terms of physical activity as such. ... the "value" would vary depending on the persons from whose point of view the work is evaluated. ... At the risk of over-simplification we can distinguish between three different aspects of employment: (i) *the income aspect*, employment gives an income to the employed; (ii) *the production aspect*, employment yields an output; (iii) *the recognition aspect*, employment gives a person the recognition of being engaged in something worth his while.' The three aspects of employment can be illustrated by considering a member of a peasant family. Is he employed? could mean: (i) "production": If this man leaves the family would the output of the family enterprise go down? (ii) "income": Is this man's income a reward for his work, and will he cease to get it if he stops to work ? (iii)" recognition": Does he think of himself as "employed"? Do others?
In a review of Sen (1975), Stewart (1976) remarks: 'While "employment" is widely described as a (sometimes the) major problem of underdeveloped countries, there is confusion about how employment is to be defined, how measured, and how the problem, if there is a problem, is to be tackled. Indeed, the ILO, who established the World Employment Programme to deal with the problem, who have sent Missions to many countries to analyse it, and under whose auspices this book was written, are themselves increasingly abandoning the fog of employment in favour of the apparently clearer waters of income distribution.'

125. Employment policy asks for consideration of (i) the alternative modes of production and systems of employment and (ii) the interrelationships between institutions, technology and employment. As such it is a part of welfare economics: the optimal allocation of resources - optimal being a normative adjective in the same way as appropriate.

For understandable reasons employment policies tend to concentrate on the income aspect and on wage labour. This comes out clearly, in particular, in the problem of disguised unemployment. Those who are according to the statistics unemployed may well be employed in the income and recognition sense of being employed.[126] Hence, "providing jobs" may not have the expected effect.

A second measurement problem relates to evaluating the effect of development programmes to see whether "poverty has changed". To measure poverty, two problems have to be solved (a) which individuals should be called poor, and (b) the construction of a poverty index. Assume that one uses income as a poverty index, then (a) leads to the problem of determining real income. (Poor people in LDCs have virtually no money income.) Secondly criteria would have to be chosen to weigh different changes in income. For example, most poverty indexes are insensitive to a transfer in income from a poor to a rich person, other things being equal.[127]

2.1.4 Implications. The interest in poverty has affected all development theories and policies. In chapter 3 the details of present day opinions are summarized. Here, I give just a brief view of the macro-developments in (a) analysing the causes of increasing poverty, (b) the theoretical possibility of eliminating poverty, (c) the resulting "new" development policies.

(a) Causes of unemployment. 'The employment problems of Third World countries have occupied the centre stage in the development literature

126. 'The Indian National Sample Survey reports that in 1961-2 among the group of rural workers with only 15-28 hours of work per week, only 27 per cent said that they were available for additional work if offered. Among workers who had only 1-14 hours of work per week, the proportion willing to accept additional work was even lower, viz. 23 per cent.' (Sen, 1975, p. 39). Consider also whether the following people are employed: those digging and filling holes or filling in forms for the state, housewives, thieves, beggars, and the man that runs a "beggar's business."

127. Common poverty indexes are: m/n with m the number of people in a total of n, having an income below the poverty line; and $\Sigma y_i/mz$ with z the poverty line and y_i the income distribution (hence this measure is a kind of aggregated distance to the poverty line). The first measure is also non-monotonous, that is, if the income of a poor person decreases, the poverty index does not change. Sen (1976) proposes a poverty measure that fulfills most reasonable criteria.

and the activities of research institutes for almost a decade. It has been claimed that: a) factor-price distortions encourage the selection of capital-intensive technology; b) existing technology is inadequate since it was developed for factor availability in countries where technology was created, and this differs considerably from factor supplies in Third World countries; c) little effort is made to adapt technology due to the low level of research and development by local firms and/or governments, and the unwillingness of subsidiaries of multinationals to make technological adjustments; d) high concentration in the distribution of income results in a demand profile which favours the establishment of industries with capital-intensive technologies, catering to this demand for high-income-elastic products.' (Baer, 1976.)

(b) There does not seem to be a limit to the growth of world models. Some of these models concentrate on people and may find that: 'The results of the model set out in the previous chapter demonstrate that, if the policies proposed here are applied, all of humanity could attain an adequate standard of living within a period a little longer than one generation. The satisfaction of the most essential physical and cultural needs, which has been one of the central objectives of man from his beginnings, could be fulfilled for most of the countries of the Third World toward the end of the century, or in the first years of the next. The obstacles that currently stand in the way of the harmonious development of humanity are not physical or economic in the strict sense, but essentially sociopolitical. In effect, the growth rates with which the desired objectives are achieved are, as was seen in the previous chapter, those considered normal in the current economic situation. The goals are therefore achieved not by very high economic growth, but by a reduction in nonessential consumption; increased investment; the elimination of socioeconomic and political barriers, which currently hinder the rational use of land, both for food production and for urban planning; the egalitarian distribution of basic goods and services; and, in developing countries, the implementation of an active policy to eliminate deficits in international trade.' (IDRC, 1976.)[128]

(c) As in 2.1.2 there are numerous ways of classifying the factions in developed theory of the poor. One way is as follows:[129]

(i) The diffusionisticapproach keeps to the traditional theories: development policy up till now has been basicly right. The only problem is that the poor are lagging behind. Hence special programmes for the poorest are needed.

(ii) The emancipating approach. This view also keeps to the traditional, but now marxist theory. The increase in poverty and unemployment is the well known *Verelendung*. Only a social revolution, overthrowing the elite, and supported by the great masses of the poor can solve the problem. Most writers agree that this theory could be true, but does not provide any practical perspective.

(iii) The basic needs approach. This approach stresses that all development effort should be directed to producing products that fulfil the basic needs of the poor (food, shelter) and can best be implemented by generating as much employment as possible.[130] This approach has recently been institutionalized by the ILO (see section 3.1).

(iv) The indigenous approach. The major characteristics of this ap-

128. Other interesting conclusions of IDRC (1976) are: 'The only problem of physical limitation that arises, and which is of a local nature, is the exhaustion of the supply of cultivatable land in Asia in the middle of the next century. However, the large reserves of cultivatable land in other regions could easily cover this deficit. One of the most interesting results of the model is the light it sheds on the effect that possible international aid, in particular the transfer of resources from the industrialized countries to the poor countries, would have. Even if a greater level of international aid than that advised by the United Nations is implemented, it may contribute to raise the level of well-being at the time of transfer, but in no way decisively. What has been seen with regard to income distribution clearly demonstrates that international aid, in the conditions currently prevailing in most developing countries, would only contribute to increasing spending by priviliged sectors, and would have little or no effect on the living conditions of the majority of the population. The effect of the transfer of capital is only significant for the general well-being if there are conditions of social equality similar to those proposed in the model.'

129. The first three categories are used by Hommes (1977). Although the fourth is related to the second and the third, I think it deserves a special category.

130. This aspect is discussed in detail in sections 3.1 and 3.2. It may be stressed that maximizing employment is a non-economic criterion.Whether employment is a social benefit or a social cost, is an integral part of the conflict "jam to-day versus jam tomorrow".

proach are: No meaningful development can take place if the development process depends on outside factors either of capital or expertise; it must be intimately interwoven with the fabric of society; manpower in an underdeveloped area must be used to the fullest extent; development requires a big push, based on the least scarce resources; a developing economy must be equipped with the necessary inducements for all those with entrepreneurial potential.

2.2 Development policy and technology

2.2.1 Science and technology policy.[131] In the terminology of this report, "technology" includes science as far as the latter is or may be relevant for production. I shall, however, use the more common abbreviation "S & T policy" to refer to those policies that intend to further the knowledge about production systems. We may distinguish three groups or types of influences on activities related to the production, diffusion transfer and utilization of scientific and technical knowledge:

(a) Explicit S & T policy and instruments: Policies are such things as a statement by a high level government body; and a policy instrument constitutes the set of ways and means used when putting a given policy into practice, e g a legal device or an organisation put in charge of implementing the policy. Policies do not always have the effect they intend to: (i) The institution used as an intermediate may

131. This section is based on IDRC (1976a) which describes: 'The Science and Technology Policy Instruments (STPI) project is a cooperative research effort undertaken by 10 research teams from Africa, Asia, Latin America, and southern Europe. The general purpose of this project is to gather, analyze, evaluate, and generate information that may help policymakers, planners, and decision-makers in underdeveloped countries to orient science and technology toward the achievement of development objectives. How science and technology variables act on national objectives is a subject that is abundantly explored in the vast literature about science and technology and their relations to development. However, much less is known about the process of formulating and putting science and technology policies into practice, particularly in less developed countries. Consequently, the specific purpose of the STPI project is to explore how policymaking and policy instruments (independent variables) influence science and technology functions and activities (dependent variables) in the different contexts of underdevelopment.'

modify or distort the message. (ii) The resulting policy often comes about as the result of piecemeal decisions of many agencies, enterprises and such without or in spite of an overall centrally guided policy.

(b) Implicit policy and instruments: Many policies and decisions aimed at functions and activities other than science and technology may have unintended effects upon the latter. These effects are seldom taken into account in the design of policies and policy instruments, and policy makers have, at best, a dim awareness of them. Typical examples are: interest and exchange rate, use of foreign manpower, income policy, policies to modify the general value structures, purchasing decisions of large firms.

(c) Contextual factors or boundary conditions: These are aspects of the social system concerned and its physical setting that cannot be changed in the short run. Three different types may be distinguished:[132]

(i) the physical-geographical setting (climate, location, ...);

(ii) sociocultural structure (cultural traits, relations of production);

(iii) factors resulting from long-term cumulative policymaking (e g behaviour and attitude of entrepreneurs).

The contextual factors are fixed boundary conditions when making in-

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132. 'Other relevant contextual factors may be briefly mentioned: . cultural: habits of cultural dependence; ties of scientists to the international network of science; unfavourable value structures, attitudes, norms, etc., such as disdain for manual labour, humanistic and anti-scientific traditions, attitudes toward women's labour; structure of status and prestige, etc. . social and demographic: low educational levels, internal and external brain drain, deficiencies in the educational system, poor labour mobility, unavailability of skilled manpower, poor health, overpopulation, heavy rural-urban migration, structural unemployment, etc.; . political and institutional: national development objectives not well defined; lack of awareness of the potential role of science and technology in development; habitual lack of coordination between policies emanating from various first and second level sources; heavy-handed and slow decision-making procedures; excessive red tape; slow and complex control of expenditures; corruption; poor control of the implementation of government policies and decisions; fossilized institutions and mechanisms that subsist long after they stop being useful; inefficiency of public administration, etc.; . geographical, physical and ecological: lack of certain natural resources; poor transport and communications within and without the country; ecological problems; climatic factors, etc.'

vestment decisions and choosing production systems. This, however, should not prevent us from asking "can they be changed ?", because the choice of product and production system will effect how these long-range parameters change in the future.[133]

The policies and instruments effect the S & T activities, which may be classified as follows:

(a) demand side: behaviour and decisions in production units; demand for and absorption of technical knowledge and know-how;

(b) supply side: R & D, services, skilled manpower;

(c) linkage area[134]: linkage between (a) and (b) in one country, transfer of technology.

The resultant policy will usually contain many contradictory elements and the effect of implicit policies is often greater than that of explicit policies. 'For example, it is generally recognized that fiscal incentives for the performance of R & D in industry are a relatively weak instrument in comparison with credit mechanisms that motivate the entrepreneur to acquire technology abroad.'

2.2.2 S & T for LDCs. A recent editorial in *Science* opened as follows:[135] 'More than 2 years after the U.N. decision to convoke a World Conference on Science and Technology for Development in 1979, and less than 2 years before it actually takes place, our understanding of the links between science and technology and the development needs of the Third World is still very slim.', and continued noting the overworked observations that LDCs lack a general S & T culture and that the local R & D activities are completely isolated from both educational and productive systems. In chapter 4 I shall give some microobservations of R & D institutes in LDCs. Here attention should be focused on the social function of S & T in LDCs, as distinct from their formal function.[136]

133. I am aware of the fact that it may prove difficult to change the climate.
134. 'The key importance of the linkage area lies prècisely in the fact that it is often the missing element in the structure of the industrial "branch" and that if left to spontaneous development, it can even become a barrier to communication between productive units and units that supply technology.' (p. 61)
135. Miguel S. Wionczek of *El Colegio de México* in a guest editorial of *Science* from May 20, 1977.
136. Following Cooper (1974) inserting a few personal prejudices.

The development in the industrialised countries has been such that technical development generated skills at the interface between science and production: engineering and design. One might say that the engineers working at this interface convey the needs of the entrepreneur (or occasionally society) to the scientist. In that way economic, and more recently social demands, affect the development of S & T.[137] Now the economy of underdevelopment is very different, in particular in view of its relation to the economy of development, and asks for its own theorisation.

That the situation is different in LDCs is so clear that one wonders how it is possible that universities, R & D institutes, academies, etc. are still set up according to the models the external advisers have been educated in. S & T in LDCs is a consumption good, not a capital good because of technical dependence: (a) Elite consumers in LDCs ask for known existing western goods: S & T for these is available and need not be developed. (b) To a lesser extend the same applies to agricultural techniques and machines and other techniques needed to produce products for "basic needs". (c) There certainly are S & T problems typical for LDCs, but the S & T/R & D structure in overdeveloped countries is so dominating that these problems either are absorbed and exploited, or outdated before any S & T result in an LDC is reached. (d) The R & D institutes in LDCs are themselves consumption goods because they have no output and deprive tradional sectors from investible resources.

If S & T development should have a place in underdeveloped economies[138]

137. Hence economists should give up the idea that technical knowledge is economic data, it is an economic parameter, which can be steered. '... een van de eerste vereisten is dat de economische wetenschap de technologie niet meer als een gegeven beschouwd dat als zodanig buiten het onderzoek gehouden wordt, maar als een variabele die gemanipuleerd kan en en moet worden, o.m. door het gebruik van economische criteria.' (Boon, 1976).

138. Intricate models have been made to derive an S & T policy from a development plan, but of course the outcome of the model depends on the opinion of the specialist regarding the relevance of certain disciplines, skills and institutions. An example is Cetron and Connor (1972), advocates of technology assessment: 'Step 14. Subtract ratings in the "capability" profile column from corresponding ratings - in the "relevance" profile column. This then is the "GAP" profile rating which is by and large identical with the profile of institutional needs in science and technology.'

first and foremost some boundary conditions should be questioned and changed. Decision makers prefer foreign engineers because they are better. There should be no doubt: they *are* better, but how would indigenous engineers ever learn if they have no oppertunities of "learning by doing." I shall pursue this aspect a little further in chapter 6.[139]

2.2.3 Development planning. For economists development planning is investment planning; from there all other policies and instruments are derived. It is useful to distinguish four levels of decisions:

(a) How much do we invest and what are the general boundary conditions which have to be recognized ? This is the level of the economic model. The economic model includes the basic choices with respect to external relations (foreign investment, etc), and whether the emphasis is on heavy industries, agriculture, and similar.

(b) In what sectors do we invest ? This applies in particular to how the investments over various groups of manufacturing industries should be divided. On this level one chooses between, say, textile production and fruit juices. Above a certain degree of industrial development input - output analysis[140] is used.

(c) Which specific projects shall be undertaken ? This includes the choice of product or restraints set on the use of other production factors. At this level social-cost-benefit analysis might be used[141] - relative to the general goals set in the development plan.

(d) The micro techno-economic choice of production system. On this level it is usually assumed that the specification includes all value aspects, so that engineers and economists have to make a purely technical best choice.

The most common situation is that there is on the one hand a development plan stating in general terms that all sectors of the economy

139. See also note 151 and sections 2.5 and 3.4.

140. Input - output analysis is a statistical technique, describing in quantitative terms the inter-relationships of the major economic activities, in particular those in manufacturing industries. The empirical relation between input and output is the production function of the activity considered. Usually input-output tables give inter-industry transactions, e.g. ships to transport and for fishing. One may view input-output analysis as a technique to specify an economic model.

141. Social-cost benefit analysis is often seen as a panacea. The technical problems in applying it are, however, enormous. It has its limitations and must be applied with great care (Griffin and Enos, 1970).

are of basic importance, that there should be growth, employment, in short welfare for everybody; and on the other hand a lot of people working on level (d) using their own prejudices to fill in levels (a) - (c), and of course in favour of their own specialism.

For projects that are very large relative to the economy concerned, levels (a) - (c) merge and planning committees or similar bodies will be busy at the national level in ranking projects like a cement factory, an irrigation scheme, a railway, a sugar factory, a drainage work, a steel mill and an iron ore mine. It will be clear from this list that the ranking will be different depending on the question how many projects can be entertained in say five years.

2.3 Industrialization and development

2.3.1 Summary of negative effects. I have not made an empirical investigation, but I estimate that at the present moment at least one book a week is published on the negative results of development planning over the past 30 years.[142] This report does not deal explicitly with that subject, but I shall give some selected background information on the effects of industrialisation on development in this section.[143]

On average the effect of industrialisation in LDCs could be summarized as follows:[144]

(a) Industrialisation and related "modern" investments are financed with capital that, directly or indirectly, comes out of the agricul-

142. The first sentence of all these books is the same: 'In the course of the First United Nations Development Decade, it has become clear that the transfer of up-to-date capital-intensive technologies from the more developed countries has been accompanied by and linked with a pattern of development in which a fairly rapid growth of output in the modern sector, or even of over-all GNP, has gone together with widespread and increasing unemployment and underemployment, growing internal inequalities and social tensions and stagnation in the traditional (typically rural) sector.' (UN, 1971.) 'Trotz weltweiter Initiativen während der vergangene 25 Jahre, die wirtschaftlichen und sozialen Lebensverhältnisse in den Ländern der Dritten Welt nachhaltig zu verbessern, konnten befriedigende Ergebnisse bislang nicht erzielt worden.' (Agarwal et al, 1975, p.1.)

143. Although often reference is made to agriculture in this report, I refrain from anywhere mentioning the Green Revolution.

144. Following Hommes (1977).

tural or extractive sector, while, in particular agriculture, needs capital itself so very much.[145]

(b) Industrialisation is directed to (i) producing consumption goods for the elite, (ii) producing goods for infrastructural investments which modern industry needs itself, and which for the rest, mainly serve the elite (electrification, sewage systems), and (iii) goods directed to agriculture (tractors, fertilizer, pesticides), but these do not seem to reach the small farmes.

(c) Production systems installed produce mass consumption goods with capital-intensive methods, thus destroying the small production systems that had been producing these goods until then.

(d) Industrialisation and the accompanying investments in inappropriate education lead to mass migration and an unproductive bureaucracy that is only working for the elite.

The major argument against this type of analysis is probably that this is exactly what happened, and was succesful, during the industrial revolution in Western Europe (and the Sovjet Union some will add). The discussion than may go on by referring to the fundamentally different boundary conditions, in particular aspects of dependence and world trade. But I won't pursue this line further.

2.3.2 The problems of capital-intensive industries. Economic arguments for capital-intensive production systems have been usually of three types:[146]

(a) The neo-classical view that (i) reality is as described in books on economics, (ii) one should not plan. It follows that because capital-intensive production systems are chosen, this is what is best for development.

(b) The deterministic view according to which, given the decision in what to invest only one choice is actually available: this appears to be a capital-intensive production system. Choice of product or sector is a given data.

145. See for some details section 3.2.5. Even in countries such as Tanzania which have a very explicit and serious policy to favour rural development, there is still a net flow of capital from the rural areas to the urban centres.

146. These three schools are e.g. identified in Stewart (1974).

(c) Those emphasizing the so called reinvestment criteria: the rate of return on investment is highest in the most modern capital-intensive production systems. Hence, development will be faster in terms of increasing output. Reinvestment models undervalue or even forget about the necessity of generating consumption.

Because capital-intensive modern production systems are chosen for investment the major mechanism in bringing them about is transfer of technology. In 1.6 I have mentioned the major obstacles to appropriate transfer for a given project. Here I list the major macroeconomic effects of the transfer of capital-intensive goods and production systems:[147]

(a) Although there has often been an increase in output, this has not been enough to counterbalance population growth.

(b) The transfer leads to the emergence of a class and tends to redistribute income in favour of capital.[148]

(c) Taking all leakages into account, it is often highly disputable whether any profit in terms of either foreign exchange or costs minus goods valued at world market prices, is made.[149]

(d) The transfer is in particular in the interests of the donors, because they can thus not only increase their markets, but often can provide products from "mature" production lines as well.[150]

(e) Large-scale industries may have educative value in training

147. See out of many Rweyemanu (1971, 1973), Onyemelukwe (1974), Cooper (1974).

148. See Pilgrim (1974) and '.... if the foreign technology is too capital-intensive in relation to capital-labour endowment of the recipient country, not merely does it reduce the total social benefit that accrues from the transfer, it also tends to redistribute income in favour of capital.' (Bardhan, 1975.)

149. There are returns to donors in a variety of ways that are difficult to control. The principal forms of leakage which are a feature of most underdeveloped economies are as follows (Onyemelukwe, 1974, p. 16.): '(a) tax rebates to encourage foreign investments; (b) export of normal and accelerated depreciation and profits by foreigners; (c) export of salaries and other financial inducements paid to foreign personnel invariably required; (d) fees for consulting and other special services to outside groups; (e) payments to skilled foreign construction and administrative personnel (most major projects are executed by foreign firms); (f) recurrent costs of buying spare parts from the advanced countries; (g) recurrent costs of buying raw materials, tools and other production aids from the advanced countries; (h) other leakages arising from overpricing of foreign goods for construction and industrial use.'

technicians and operators. Their educative value or initiative potential for local entrepreneurs is however negligible.[151]

By far the best example of the effect of the capital-intensive policy is in India. The philosophy of the first development plan has been succesful in that India at this moment is the world's twelfth or so largest producer of steel, its industry produces jet planes and atomic plants, and the increase in the infrastructure has been considerable. However, discussions about the poverty in rural areas centre round the question of whether it has actually been increasing over the past 15 years, or remained constant; whereas the Indian urban problem is now well known to be one of the major social challenges of our time. Of course, optimists, like soothsayers, will argue that we have just had a few years of bad weather.[152]

A brief remark should be added on the problem of "shiny" projects.

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150. In traditional economic theories of world trade (cf. note 121) the argument goes that by investing in "mature" production systems LDC's can produce at low cost, because there are no innovating costs, and markets are large. However the "mature" stage is never reached in the present context of overdevelopment. New products, perhaps less optimal than the old ones, are continually introduced. As far as coca-cola is concerned, that stays as it is because the name is sold and not the product. (I just read in the newspapers that the Government of India has plans to throw out Coca Cola.)
151. The Soviet policy in the 1930's was directed toward labour substitution *and* geared to the level of emerging skills and managerial capabilities. (Granich, 1957). (The first Indian five year plan derived much from Soviet experience.) The situation in developing countries is however very different. Kilby (1965) shows convincingly for Nigeria that the only thing that has contributed to enduring industrialization is the presence of indigenous West Indian and Levantine businessmen. The modern advanced industry is too sophisticated to integrate or give significant learning opportunities. Compare also section 2.4.3 and the following quotation from an advertisement in local papers of "The Nigerian Society of Engineers": 'The Society is amazed that in a country with two or three Universities producing graduate engineers, most of whom have not been able to secure employment in the engineering field, government officials should continually feel that our development projects can only be conceived and executed by foreign engineers..... For instance, the Kainji Dam, the largest engineering project ever undertaken in Nigeria, produced no benefit to the country in engineering manpower development.... If Nigerian graduate engineers cannot get employment on engineering projects in Nigeria, how are they to obtain their practical training and experience?' as quoted by Onyemelukwe (1974, p. 30.).

There is a tendency to lay emphasize on ultra-modern highways, conference centres, oil refineries, and the producers of golden beds. However, universities, large dams, cheep sandal factories and also hospitals come in the same category.

2.3.3 The problems of import substitution.[153] The effect of import substition policies (in order to reduce foreign dependence, increase industrial employment, strengthen the balance of payments) that is - its failures, in particular in Latin America - have been documented in detail.[154] The typical characteristic of an economy in which such a policy prevails are:[155]

(a) Deformed price formation mechanisms: credit and fiscal measures biased toward capital, in particular foreign equipment; tarif barriers and overvaluation of exchange rate; highly developed social policies for labour in the modern industry; monopolies.[156]

152. Even in those rare cases in which the classical development approach works (in that there is a rapid growth of GNP) there remains the question of who benefited from the growth. For example, with respect to the Ivory Coast: 'Tels sont les traits essentiels qui se dégagnent d'un document de travail du Ministère du plan. Loin de présenter la croissance ivoirienne comme une sorte de gâteau dont tout le monde aureait profité entre 1960 et 1970, ces traits emfirment le caractère *asymétrique* du développement national. (....) Bien loin d'affirmer que "tout le monde a gagné quelque chose" durant la première décennie de la croissance ivoirienne, Mohamed T. Diawara et les techniciens du Plan conviennent que celle-ci n'a pas été bénéfique à tous les nationaux, et que certaines régions ont polarisé les effets de la croissance au détriment d'autres.' (Diabaté, 1973.)
153. On the barriers against free trade Lipton (1974) remarks: 'However, both the rich and the poor *nations* lose from the resulting misallocations. Unless powerful *groups* within each nation gained from the barriers, they would go. The question, Can rich countries, in helping poor countries, help themselves?, suggests another: Can such groups be defeated, bribed or compensated?'
154. See e.g. the special issue of *World Development*, Jan. 1977 on Latin America in the post-import-substitution era and references given there.
155. Characteristics derived from IDRC (1976a), but ordered differently. Already in 1964 Johnson stressed that 'Import substitution policies on the part of developing countries often result in the establishment of inefficient industries using inappropriate technologies. Engineering costs to adapt techniques are prohibitive and transmitted techniques are ill-suited to small markets and restricted production environments of newly industrializing areas. The establishment of plants requiring sophisticated manufacturing materials and equipment generates new import demands that defeat the intended purpose of alleviating balance of payments difficulties.'
156. While inflation, which is usually a consequence of this type of policy, adds to this.

(b) Technical dualism: a few advanced firms, usually connected with foreign corporations, coexisting with a large number of backward ones.

(c) Predominance of foreign investment, because technology and techniques are transfered from abroad.

The effect of this is first conservatism of local entrepreneurs and underutilisation of existing capacity,[157] because there are no incentives in the protected environment to take any action. And secondly gross inequalities in income distribution because of the orientation of production to the small segment of the population with high income and the use of income from agriculture to finance industrialisation.

2.3.4 The problems of rural development. In evaluating rural development programs the following aspects have been noted:

(a) In national development plans, often not more than lip service is paid to rural development, because de facto (see previous subsections) the rural areas are drained of money to finance urban development.

(b) Programs appear to reach only the high income group in the rural areas. In extreme cases this group may consist of conservative land owners who invest their profits in industrialized countries.

(c) Introduction of inappropriate techniques and tools affect in particular the poorer farmers.[158]

(d) Visiting experts offer programmes without any awareness of the circumstances in which they are expected to operate. Even a group of "voluntary" workers" staying for two years or urban-based indigenous rural development workers are not succesful in initiating self-generating development.

(e) Also in rural development there is the effect of easy succes.

157. 'The under-utilisation of capacity has however not been a barrier to profitable operations as might be expected. Heavily sheltered from foreign competition by tarriffs and endowment of nearly complete monopoly by governmental regulations, industries have not been slow to realise that diseconomies of underutilisation of capacity is clearly preferable to greater labour utilisation with its concomitant problems of management.' (De Silva, 1974.)

158. 'The inappropriateness of many new technological developments could still be best illustrated by development aid examples. Nearly all countries represented in the Workshop had imported a great deal of agricultural machinery after they had become independent. This machinery could not be used, due to lack of know-how.' (DSE, 1972.)

This leads for example to much emphasize on increasing yields, which shows itself, and neglect of post-harvest losses.

(f) It has become a commonplace now, that macroplans developed without microknowledge, just do not get implemented and are therefore bad plans. This applies to the technical implementing, as well as cultural factors.[159]

(g) Finally, as with all plans, there is the problem of those involved in implementation, forgetting what it was about.[160]

On the whole, it seems to me that evaluation of rural development programs is even more difficult than that of industrialisation programmes. It appears that even such a seemingly simple question as the impact of tractorisation on agricultural output and employment is beset with such difficulties that a definitive cost-benefit analysis of this technical change is out of the question.

2.3.5 General evaluation. The previous sections should not be interpreted as saying that there is somethingbasicly wrong with industrialisation in itself. The reason that all particular develop-

159. A technical problem is that the effect of promoting the use of synthetic fertilizer can be that farmers use ten times more fertilizer than needed (because they *want* to increase their yield and *believe* now that fertilizer can do that). Yields than do not increase and trying to change attitudes once more will be a serious question. A cultural problem is (Epstein, 1975): In New Guinea cocoa planters sold cocoa for a much lower price to Chinese traders, instead of to the newly established state cocoa buying agencies, although indigenous local leaders supported the government policy. Microanalysis showed that the prevailing matrilineal system implied that money earned by sons would go back to the father's family when he died. Sons *and* fathers sold to Chinese traders, who kept no records, to circumvent the "old-fashioned" inheritance system. When the government agencies did away with their records this worked like magic. This is a good example for anthropologists to show that economists are dangerous people and will always fail. (On the other hand there is a tendency among those anthropologists who are concerned with development (instead of being interested in strange structures) to sit behind their hard wood desks in air conditioned rooms to ask the technologist for perpetuum mobile and in doing so spend paper.)

160. 'The prevailing approach in many sectors of SRDP is strongly reminiscent of a sports club which states its principle as "sportmanship" and its objective as "the development of healthy minds and bodies", then assumes that all its activities adhere to its principle and promote its objective in some vague yet incontrovertible way, seldom if ever stopping to check the validity of this assumption critically and objectively.' (IDS-Nairobi, 1972, p. xviii.)

ment strategies fail is not so much that they are all wrong in theory, but the fact that the real obstacles to development lie in social and political infrastructures ill-adapted to furthering a dedrease of dependence of international relations and to the exploitation and absorption of technology that is available.

2.4 Chemical industry and development

2.4.1 "The man in the street." 'The chemical industry is one of the dynamic sectors of a modern industrial economy; on the average, it has a growth rate about two-thirds higher than that of the national economy as a whole. The chemical industry also expands faster than the average for all manufacturing activities.'[161] It is therefore not surprising that the first major international meeting on industrial development, convened by UNIDO in Athens in 1967, noted with regret that 'In most developing countries, the chemical industry is still in the early stages of development', and therefore 'It is essential to find ways and means of promoting an accelerated development of this industry and improving the operational efficiency of existing enterprises.'

The interest of chemists and chemical engineers in developing countries is, however, rather limited. Last year the "World Congress on Chemical Engineering" took place in Amsterdam. The goal of the conference was 'to confront chemical engineering disciplines with main world problem areas so as to orientate chemical engineering research and development activities towards an improved service to the future society ', but the organizers did not consider including a section on chemical engineering in and for developing countries. In glancing through industrial engineering journals it appears that there is at least some interest in developing countries, vis à vis the problems of earning money in these* remote places. Earning money basicly may take two forms: investing and selling. As to investing the president of Dow Chemical Pacific puts the main problem as follows:[162]

161. Quotations in this paragraph from UNIDO (1969, p. 1, 65).
162. Mr. R.W. Lundeen in a contribution to "An examination of the international forces impacting on the American chemical industry" in "Chemical Engineering Progress", Febr. 1977.

'These attitudes (i e "of an increasing nationalism that manifests itself in pressure for local controlling equity in companies, for nationalisation of management, and for limiting foreigners' employment") are understandable and explainable, but they can discourage precisely the type of foreign investment which these countries may need.'

Such attitudes lead to catalogs full of vexations:[163] 'Launching a joint venture in a remote overseas location ? No one claims it is easy, but what happened to Du Pont and its Salgema S.A. chlorine-caustic soda project in Brazil is a study in frustration that illustrates the many things that can go wrong when multinationals get involved in such enterprises.'

Poor multinationals. Their second problem is selling their products. For example:[164]

'Some difficulties in the supply of clinkers has made it necessary to exploit African deposits like the one at Alva', and:

'Very little ordinary soap is imported, mainly because of the quite satisfactory products made by the local soap works.(...) It seems possible that the situation may be brighter in 1973 and 1974, as the Savonnerie Tropicale encountered some difficulties which entailed loss of ¾ of its capital', however:

'We think it would be rather difficult for any pharmaceutical companies established in Africa to mass produce profitably the wide range of products covered by section 30-03 of the Brussels Nomenclature. In any case, all of these products are protected by patents', in short, as *Chemical & Engineering News* remarks knowledgable in its "World Chemical Outlook '77":[165]

'At stake is nothing less than what the developing countries call "the new world economic order" - that is, the redistribution of wealth from the rich countries of the North to the poor, developing countries of the Southern Hemisphere.

Very little has been done on the effect of chemical industrialisation on developing countries. However, in line with the conclusions

163. McCrary in "Chemical Engineering" of April 11, 1977.
164 The next three quotations are from the special issue of "Marchés Tropicaux et Méditerranées": Le Marché Africain et Malgachie, Dec. 20, 1974.
165. "C & E News", Dec. 20, 1976.

set out in section 2.2 there seems to be general agreement that

(a) 'The total lack of any effective technology transfer was a major reason for the very limited effect achieved by aid programmes launched after World War Two.' [166] Common design errors are listed in the next subsection. In section 3.3 present day opinions on appropriate transfer of chemical technology are discussed.

(b) The weak bargaining power of the receiving country affects the benefits it draws from chemical industrialisation: subsection 2.4.3.

(c) The macroeconomic effect of the chemical industries, when compared with alternative investment possibilities, is disputable: subsection 2.4.4.

(d) The world market for chemical products and know-how presents structural constraints for developing an indigenous chemical industry: subsection 2.4.5.

2.4.2 Common design errors. Many of the microeconomic failures of transfer of chemical plants are due to lack of critical attitude of the engineers involved. From a survey of a large number of chemical plants established in Latin America Giral (1972) compiled the following list of pitfalls:[167]

(a) building designed for snow loads or hurricane loads;

(b) unnecessary insulation or building layout influenced originally by central heating or air conditioning;

(c) closed buildings or indoor installations where outdoor installations are acceptable;

(d) use of vertical building layouts, in cases where a horizontal layout should have been choosen - given different boundary conditions;

(e) use of imported construction materials where indigenous materials of construction would do a good job;

166. To reassure those loosing belief in chemical engineers: This quotation is also from a chemical engineer: M. Jones (BP, ICI, Batelle) in "The Chemical Engineer" of Sept. 1975.

167. See also Onyemelukwe (1974, p.p. 33-35) who stresses: safety factors not adjusted, overdesign (to get more aid), neglect of local materials, problems due to standardization. 'The basic mistake which continues to be made is that a process engineering design developed in a Western country is not necessarily going to work efficiently without modification in a developing country.' (Jones, 1975.)

(f) use of labour-saving techniques in construction where abundant labour is availabe;

(g) design of foundations (including burying pipelines below frost level in tropical countries);

(h) design for sea level, while actual altitude was such that compressors and spraydriers may work at 60% efficiency and reaction times in open kettles in aquous media may be twice as long;

(i) relation between atmospheric humidity and drying (unneccessay dryers in desert areas, product too wet in tropical areas);

(j) difference in trade-off between production time lost and cost of stand-by equipment;

(k) unsophisticated elimination of sophisticated control equipment.

The reader may tend to believe than engineers cannot make such simple mistakes as those listed above. However, the designer sits in his New York or London office and knows that the marginal cost of using or selling an already existing plant design is zero for the owner of that design.[168] Two causes can be distinguished for the fact that the design is not modified to suit his new environment:

(i) The motive for installing a plant is in rare circumstances purely economic, usually it is of a strategic nature. It therefore does not matter whether it is a multinational or a government that wants the plant.[169]

168. 'The marginal cost of using or selling an already developed technology is zero for the owner of that technology. Where cases of adaption arise, the owner incurs certain costs which can be estimated and usually do not exceed a figure in the tens of thousands of dollars. In several industries the sellers of technology to developing countries have themselves copied such technology from the originators who incurred the R and D expenses. On the other hand, from the purchasers point of view, the marginal cost of developing an alternative technology with his own technical capacity might amount to millions of dollars. Or he might be unable to develop it, or at least think so, in which case his relative marginal cost is infinite. Given market availabilities, the price between zero or tens of thousands of dollars, and millions of dollars or infinite is, in turn, determined solely on the basis of crude relative bargaining power. There is no price which a priori can be claimed to be more or less appropriate within the two limits specified.' (Vaitsos, as quoted by Jones, 1975.) On the other hand: 'One of the engineering contractors is convinced that in many cases it would be better for underdeveloped countries to install simpler processes of the batch type since this would mean, in the firm's opinion, lower investment, simpler

(ii) The weak bargaining power of the government with respect to the multinational or the contractor, to which we now turn.

2.4.3 Bargaining with multinationals. The problem is simply that: 'No matter how many warnings are issued, and case histories published of failures in technology transfer, costly mistakes will continue to be made so long as there is an inadequate supply of trained and experienced process engineers attempting to carry through an industrialisation programme by acquiring process technology and know-how. The solution to this problem must lie in the ability of the developing country to provide skilled manpower of the particular calibre required.' (Jones, 1975) The general aspects of this problem have been discussed

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maintenance, more use of cheap labour, and easier operation more within the grasp of poorly trained local technicians. But the firm has found that its prospective overseas clients are very unwilling to accept this sort of advice; they demand the most advanced techniques, presumably for reasons of national prestige. The firm has been forced to bow down to such requests in order to avoid losing a client to a more obliging competitor. It is clear that this kind of attitude on the part of overseas governments and clients must be added to the list of influences inducing designers to adhere to more advanced techniques.' (Aráoz, 1962.)

169. 'In many of the interviews it appeared that the main factor in the decision of a firm to install a plant in an overseas country was rooted in considerations of a strategic nature, and that economic calculations were used rather as a check. In the typical case, the company had been selling its products locally for a long time and was menaced with restrictions on its imports, or feared that a competitor might set up a plant and try to obtain protection. It was then forced to consider local manufacture, if only as a defensive move to avoid the loss of the market and to safeguard its previous investments on the distribution side. Before making the final decision, an economic appraisal was always made, with estimates of sales, investment and costs of operation. But this appraisal normally involved very rough calculations, and it was recognized that meticulous calculations would be misleading in their apparent accuracy. Since it takes between two and five years from the date of the decision to install it before a chemical plant can be brought into full operation, the preparation of a sales forecast starting so many years ahead and extending well into the future is shrouded with formidable uncertainties, particularly in an underdeveloped country where the information on which a market appraisal should be based is usually very meagre. There are like uncertainties in the forecast of sales prices, and of the costs of labour, raw materials and other factors of production. Under these conditions, estimating the profitability of an investment can give no more than a rough guide to the actual outcome.' (Aráoz, 1962.) Cf. section 2.3 on import substitution policies. Giral (1971) compared the prices in Mexico for 80 chemical products with those in U.S., they were 20-100% higher.

in 1.6. Here I give a typical illustration: the case study of two refineries in Nigeria, by Turner (1977).

In 1954 Shell-BP secured the option and in 1960 the right to build a refinery near Port Harcourt. Operation started in 1965 by the Nigerian Petroleum Refining Co. Ltd. (NPRC). It appeared that, among other things:

(a) within 18 months of operation the plant was running at full capacity (so as to realize a faster return on investment and to continue selling imported products ?);

(b) the planning of the Kainji Dam was not taken into consideration, hence the proportion of fuel oil in the output was much too high;

(c) the BP managing director was free to decide that no suitably trained and qualified Nigerians were available and as late as 1971 only 20% of the senior staff was Nigerian, although the refinery was run for a few month without expatriates during the civil war [170];

(d) during construction the London office kept the original invoices from suppliers and did not pass on discounts to NPRC;

(e) charges levied by BP for shipping materials from the UK were well above those of commercial shipping agents;

(f) very few local suppliers of materials and services were patronized by the BP management;

(g) no local R & D facilities were established: the London office was called to solve the most elementary problems.[171]

Although NPRC was 50% state owned until the 1966 coup, Nigerian members of the board had been political appointees with no special interest in the business of refining. This was changed in 1967 when technocrats with financial and engineering expertise were appointed. This resulted in a revised "Refinery Agreement" in 1972 and apparently good plans for a second wholly Nigerian owned refinery (now under construction) although there is still little indigenous experience in construction and virtually none in process design.

2.4.4 Macroeconomic effects of chemical industries. Typical for the

170. See Onyemelukwe (1974) and section 3.4.4 on indigenous technology.

171. Of course the same applies to the American subsidiary in Europe who will telex the U.S. to ask how the blades of a ventilator should be set to get maximum throughput.

effect of capital-intensive medium-scale chemical industries are, again, the investment in refineries and petrochemical industries to cater for the local market. Morawetz (1975) analysed the effect of the $ 100 million investment in the 1960s in petrochemicals in Colombia.[172] This investment followed earlier investment in less capital-intensive import substition actions ("light" consumer goods, paper) etc. Assuming that capital is a scarce production factor in Colombia Morawetz findings can be summarized as follows:

(a) Total employment in the petrochemicals and oil refining sector decreased by 290 persons between 1957 and 1965. Investment of 100 million dollars in labour-intensive export industry[173] is estimated to create 50.000 jobs, to be seen in the perspective of a total unemployment of 700.000, a total employment in the entire manufacturing industry of 300.000 and a population growth of over 3 percent per annum.[174]

(b) The foreign exchange earned and saved per unit of capital invested was on average five times as great in labor-intensive industries as in petrochemicals. Petrochemical exports are mainly directed to countries within the Latin American Free Trade Area, taking advantages of tariff preferences.

(c) The Colombian plants are about one-fifth the size of similar

172. These types of studies are rare. Most of them, not all that reliable, refer to India. A number of the references given in table 5 include similar studies. A recent exposition of the macroeconomic effects of the fertilizer industry in India is given in Eadie et al. (1976, pp. 94-98). See also chapter 5.

173. Although it is generally agreed that industries with low levels of education and skill (textile, leather, ceramics, wire products) should be selected for the first steps of industrialization, because 'Economists whose ideas of industrial policy for economic development are drawn from economic history are prone to misjudge the place of relatively recent technology in the plans for industrial promotion, and the newer chemical technologies are perhaps most often prematurely dismissed from consideration' (Meier, 1959, p. 144.), there is no hard evidence to base this on. Puerto Rico could be cited as an example of a successful development (in terms of GNP) based for a large part on chemical industries.

174. As Morawetz shows the fact that: 'Wichtiger als das heute vielfach geforderte Beschäftigungsmaximierungsprinzip der Entwicklungsländer ist hier tatsächlich die volkswirtschafliche Interdependenz der chemischen Industrie zu anderen Wirschaftsbereichen. Sie hilft in anderen Industriebereichen Arbeitsplätze zu schaffen.' (Stankiewicz, 1968, p. 97.) makes little difference.

plants in developed countries. Domestically produced petrochemicals are on average 45 per cent more expensive than imports. Hence the small scale high cost protected production of petrochemicals penalizes the industries which use petrochemicals as inputs (textiles, plastics, etc.), thus creating indirect unemployment.

(d) The only argument in favor of petrochemicals is that it saves on the scarce factor of management.

2.4.5 Mondial parameters and concluding remarks. Problems of world market in bulk chemicals, patent and licensing structure, as well as the effect of synthetic materials[175] on the world market of raw materials, are regularly discussed in the daily press. Therefore, I shall not summarize them.

Some readers will object to the biased account that has been given in the previous section: unwarranted general conclusions being suggested based on one or two examples. The problem is that there is just too little data available and those most involved may not be those most interested in case studies.[176] I think a reasonable proposal is that for any case study I have mentioned, my dear opponent provides two case studies showing the opposite.[177]

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175. The major natural products of a chemical nature that have been or are in the process of being synthesized are probably: cotton/wool, jute, sisal, leather, rubber, wood, cacao, coffee, tobacco, pyrethrum, oil and fats, dyes, nitrates, diamant.
176. As far as I can judge there is also a lack of simple descriptive data of overall activity in the chemical industry in LDC's. Metzner (1955) gives a detailed survey of the chemical industries of the world as of 1955. Freeman (1968) gives a detailed account of the contractor's business as of 1968. In chemical engineering journals large new projects are announced and they publish yearly overviews and outlooks which usually contain no data. There appear many studies and articles on individual countries and there are of course the purely statistical data provided by government agencies of developing countries. But I have not been able to find the journal which publishes every year the, say, updating of Metzner, including details of contracts entered into.
177. A number of suggestions to work on is given in section 3.2.
178. Even if, on paper, necessary resources are abundantly available, as the case of India shows.
179. To me, it seems to be wrong that countries with a per capita income of \$100 - \$500 are obliged to worry about the amount of CO_2 and other combustion gases in the global atmosphere. All other things being equal I would say that, for example, India, can claim to burn as much coal per head as Britain did during the industrial revolution and after.

My conclusion is that the effect of chemical industry on development is not different in quality from that of other large-scale industries. There is, however a difference in degree, due to the specific characteristics of presentday chemical production systems: Chemical technology is more advanced and chemical production systems are more integrated. Hence their owners have more power and it is more difficult to start on one's own.[178] Secondly, the chemical industry is very shiny. Finally, the rate of growth until recently, as well as the present state of overcapacity make it particularly difficult to select and aquire appropriate chemical production systems for LDCs.

Chemical production systems fulfil many basic needs, e g fertilizer and food processing, hence, one should be careful not to lapse into the idea that there is something basicly wrong with this polluting, awfully dangerous industry.[179] Precisely because of the impact it has, in particular by using so much of the meagre capital resources, a most careful choice of products and production systems has to be made. Some further thoughts on this matter will be outlined in chapter 5.

3. THE NEW LOOK: APPROPRIATE ?

3.1 Policy statements of aid donors

3.1.1 The pre-World Plan of Action period. That the available production techniques at any given time depend on the technology given, is, of course, not a recent discovery. In 1948 it was urged in the "Charter of the World Federation of Scientific Workers" that 'it is the responsability of scientific workers in industrial countries to help the people of underdeveloped countries with their urgent problems', for example: 'application of science to most pressing needs, e.g. development and conservation of natural resources, study of local agricultural conditions so that there may be maximum production of varied food stuffs..'[191]

In 1963 a "UN conference on the application of science and technology for the benefit of the less development areas" was held. At that time the general opinion was still very much that 'Emphasis will be laid on these new advances in science and technology which can be utilized for the acceleration of industrial development.' However, with this conference an important development started, which was the establishment in 1964 of the "Advisory Committee on the Application of Science and Technology for Development" (ACAST). The ACAST prepared the proposals for the second UN development decade (starting 1970):

'The Advisory Committee rejects the view, held by some economists, that the best hope for the developing countries lies in their acquisition of technologies that are already applied in more advanced coun-

191. as quoted by Prasad (1974). Also: 'Science has been most unevenly developed, following closely the evolution of industrial communities and being relatively undeveloped in agricultural ones.' But in the Charter there is no recognition of either the problem of cultural dominance or aspects of income distribution.

tries ... Finally, the foreign technology is often adapted to very different basic conditions, such as a relative shortage of labour, abundant supplies of capital and a large market. Developing countries, facing almost diametrically different conditions, will often find that a variant from the technology of the developed countries, and perhaps an altogether different technology, is more suited to their conditions. But the choice of an appropriate technology is not readily achieved by a country that lacks indigenous research and experimental development (R and D) facilities.'

Not much of this can be found in the declaration adopted by the UN General Assembly.[192] Also of the three targets proposed by ACAST for increase in R & D activity only the one referring to a greater striving of the *developing* countries was adopted by the UN.[193] Furthermore the World Plan of Action, in which much is said about appropriate technology, cottage industries, and similar,[194] was never formally adopted by the UN. Nevertheless the ACAST proposals have had, in the long run, a

192. The nearest "Declaration 2626" (UN, 1970a) comes to the ideas of ACAST is in the following quotation: '.... the expansion and modernization of the economies of developing countries. Particular attention will be devoted to fostering technologies suitable for these countries. Concentrated research efforts will be made in relation to selected problems the solutions to which can have a catalytic effect in accelerating development.', but it is clear that the old ideas are still there.

193. The targets were for the 2nd decade: LDC's should increase S & T expenditures to 1 per cent of their GNP; developed countries should spend 5% of their non-military R and D on 'specific problems of developing countries' and 0.05% of their GNP as support to S & T activities in LDC's (UN, 1970b).

194. The World Plan of Action says on small-scale and cottage industries: 'A large area for general improvement of productivity and product quality through industrial research and design is in small-scale and cottage industries. Industries such as tanning, weaving, carpet-making, pottery, ceramics, carpentry and food processing are invariably users of indigenous raw materials. Hence measures to promote such industry and to introduce appropriate small-scale or labour-intensive technologies also have the natural effect of promoting the development and use of local materials.' (UN, 1971, p. 17.);
and on appropriate technology: 'The questions of appropriate industrial technology and product and plant design are considered as ranking among the priority areas for concerted attack under the World Plan of Action. The high rates of growth in population, large-scale migration of unskilled labour from rural to urban areas, and the slow pace and the relatively high capital intensity with which industrialization is taking

large impact on the various UN agencies and a number of governments.

Although the World Plan lists priority areas of research, such as edible proteins and desalination, the problem is, that it is in favour of anything that might solve any one of the problems in development. As ACAST says 'the World Plan of Action is limited to recommendations directly in the field of science and technology, the Committee wishes to point out also the closely related needs for research of an economic and social nature. Programmes in social studies, in particular, could make valuable contributions to the solution of problems involved.' In short, the World Plan is not so much a plan, let alone a plan of action, but more a not very operational policy statement.[195]

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place in the developing countries may lead to a massive build-up of unemployment in the years to come. Modern industrial technology owes its origin to advanced countries where the major motivations for research and development are the saving of labour and the primary materials imported from the developing countries. The latter, on the other hand, with ample reserves of unskilled labour and the need to find greater use for their primary materials, require technologies which would substitute labour and local materials for capital and foreign exchange.' (UN, 1971, p. 18.), and continues to discuss the need for indigenous design facilities and notes that 'a number of unwarranted prejudices and built-in biases operating against the use of such specific designs will have to be overcome', while 'equipment designed to withstand overloads, adjustment to tropical conditions, special protection against dust, sand, heat and humidity etc., would contribute to reduce the need for repair and maintenance.' Further, the use of the abundant production factors (labour, local resources) is stressed, but also the need for concentrated efforts in fertilizers and petrochemicals.

195. ACAST has recommended concerning appropriate technology: 'UNESCO orientation towards the promotion of indigenous science and technology within developing countries, UNIDO concentration on developing industries and processes using local materials; UNIDO and ILO orientation towards the encouragement of small-scale industries; FAO orientation to the development of appropriate tools and equipment for agriculture as well as the development of rural processing and industrial activities; and WHO orientation towards the improvement of rural health so as to provide a more favourable infrastructure for rural development and industrialization.' But this means very little when, firstly, there are also recommendations emphasizing other activities, and secondly these UN-bodies depend on their "experts" to implement policies. A typical example is a UNESCO document of 1971 which 'geht auf umfangreiche Befragungen von Wissenschaftlern zurück' (Havemann, 1973, p. 240). It mentions 'Use of indigenous herbs in pharmaceuticals .... Controlled nuclear fusion .... Pulp and paper plants allowing the utilization of mixed deciduous forests .... Non-polluting pesticides ....', and 85 other not so original subjects, all in some sense appropriate but taken together without any operational relevance.

3.1.2 Recent UN policies. The activities of the ILO and UNIDO will be discussed separately. After the adoption of the UN strategy for the second development decade (UN, 1970a) the first major event was probably that the UN Commission for Social Development discovered in 1972 that development analysis and planning asks for a "unified approach."[196] The last major resolution of the UN - still in the process of being implemented - was taken in 1974: "Declaration and program of action on the establishment of the New International Economic Order". In the present context the contents of the Declaration can be summarized as:[197]

'Giving to the developing countries access to the achievements of modern science and technology, and promoting the transfer of technology and the creation of indigenous technology for the benefit of the developing countries in forms and in accordance with procedures which are suited to their economies.'

The different, specialised, UN agencies are expected to implement the New International Economic Order. For example, UNCTAD is expected to formulate a "code of conduct on transfer of technology". Other agencies are concerned with the same, or patents, or employment aspects, or the design of equipment, or seeing to the environmental soundness of everything.[198] The previous paragraph is primarily on policies to

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196. The reader is invited to carefully consider the following quotation (UN, 1973), because the 'concept of unified approach should be widely diffused': 'The unified approach aims at providing a conceptual framework for understanding the development process. Development is not just the achievement of a satisfactory rate of economic growth measured by the conventional yardstick of gross national product. Nor is it merely a matter of evidence of growth in various economic sectors plus progress in particular social fields. Rather it encompasses and is influenced by a whole complex of forces that pervade a society - forces that are political, social and technological as much as economic. The unified approach is an attempt to recognize these forces and to understand the manner in which they interact on each other in the process of growth and change. In spite of the foreseeable obstacles and difficulties, it is imperative to advance towards a realization of a unified approach since it appears to represent the only possible means of overcoming the problems emerging from the failures and deficiencies that have prevailed up to the present time.' Please read the quotation once more. Cf. note 2.
197. UN (1974a). The program of action expresses in the well-known long-winded jargon that all efforts should be made to take significant measures to encourage the realisation of the objective as quoted.
198. Respectively WIPO, ILO, UNOST, UNEP.

do with the dependence relationship. As to particular investment projects, UN policies seem to be slowly changing as well. The World Bank becomes increasingly interested in labour intensive projects. The UN Development Programme,[199] through which most UN technical cooperation projects are financed, is changing the emphasise more to rural development.[200]

3.1.3 UN Industrial Development Organisation. The present policy of the UNIDO is based on the "Lima Declaration and Plan of Action on Industrial Development and Cooperation", adopted in 1975.[201] In Lima it was recognized 'that problems of industrial development in developing countries at their present stage of development do not lie entirely in those countries but also arise from the policies of most of the developed countries.' With respect to the choice of production systems we read, inter alia, the following:

'The establishment of integral industries such as mechanical engi-

199. The UNDP was established in 1965 through a merger of the "UN's Expanded Programme of Technical Assistance" (set up in 1949) and the "UN Special Fund" (established in 1959). The UNDP is the largest single channel for international technical cooperation. The UNDP helps support some 8000 development projects, with a budget of US $475,000,000 in 1976. Its goal is -rather simply- 'the fuller and better use of available natural resources, and of human talents and energies'. The types of UNDP projects are: surveys to assess development assets, normal investment projects, training programmes, setting up or expanding applied research centres, economic and social planning. Although under the influence of the "New International Economic Order" the UNDP Governing Council set some "New Dimensions" in 1975, not very much seems to be changing. Phrases can be found such as 'Focus its work for more direct impact among the poorest segments of the population, particularly in rural areas, with more effort to obtain local participation in projects' and 'UNDP is working with governments and community organizations to develop indigenous and appropriate technologies', but UN-officials spending UNDP money, I met in places such as Ouagadougou or Addis Ababa did not seem to have any awareness of these developments.

200. Some readers may have missed the FAO. My experience is that nobody knows what the FAO is doing, let alone FAO itself. Typical is that about a year ago a committee of FAO was formed to make a list of all current and planned post-harvest processing projects in which FAO is involved. When I visited the FAO in April 1977 nobody was present at that moment who could tell me how much progress had been made in making the list. I then wrote a letter to the responsible department including questions on this and other matters and also sent a report on my impressions of FAO asking to comment on anything that would be incorrect or biased. The receipt of this letter was acknowledged, but no further information provided.

neering, electrical and chemical industries ... The creation of manufacturing and processing industries to satisfy the needs of the population for consumer goods ... Encouragement and support of small, medium-scale and rural industry and industries which fulfil the basic needs of the population ... every attempt should be made to promote agro-based or agro-related industries... Achievement of a higher degree of efficiency in import substitution processes ... developing countries should devote particular attention to the development of basic industries such as steel, chemicals, petro-chemicals and engineering', but I have found no statements that bear on the mutual consistency or priority of these policies.

In UNIDO, and in many other places, possible problems are discarded by coining the concept of "technology-mix":[202] 'Given these broad policy objectives, each country would need a proper mix of technologies ranging from the most sophisticated to the simple ones, whether imported, adapted or developed indigenously.' In the present context resolutuon No. 2 of the Lima Conference is of most interest. It asked

201. Many organizations and people prepared suggestions for the Lima conference. For example Tinbergen (1975) stressing the abundance of cheap unskilled labour and some natural resources and ACAST (1974) suggesting 'that the Conference might include, as an integral part of its Declaration, a statement reaffirming the importance of an appropriate choice of technologies, taking due account of the particular conditions prevailing in developing countries, which often differ from those prevailing in advanced industrial countries. This statement would emphasize that, while for certain industries the appropriate technology will be the same for developing and developed countries, there are other industries for which a range of technologies are available, some of which offer developing countries greater opportunities to employ their population, and to economize their scarce capital resources and foreign exchange' and it stressed the 'need to build up a cohesive and coordinated programme on appropriate technology' and eleven other similar lines of action.

202. UNIDO (1977b). Also: 'Appropriate industrial technology is not necessarily aligned to labour-intensive or small-scale production. Depending on the conditions it could very well be capital-intensive, advanced in nature, and for large-scale production. With changing conditions the appropriate technology would also change. These changing conditions could be the result of the development process itself. The particular form appropriate technology takes can thus change in the course of time. In this sense, appropriate technology is a dynamic concept. The appropriateness of technology may also differ among countries, depending on development objectives and different socio-economic conditions.'

the executive director of UNIDO 'to prepare as a matter of urgency a concrete co-operative programme of action to promote the creation, the transfer and the use of appropriate industrial technology for developing countries, primarily related to specific branches of industry as well as to social conditions.' This lead to an action programm,[203] produced in 1977, which list the following possible activities:

(a) evaluation and comparison of alternative industrial technologies, inter alia, fertilizers, leather industry, agro-industries, building materials;

(b) promotion of technological research; projects on, inter alia, low-grade ores, oil extraction and fractionating, decortification, natural rubber, recycling polymer wastes and industrial lubricants;

(c) collection and dissemination of practical experience on, inter alia, small-scale pharmaceutical units, agricultural waste utilisation in paper making, medicinal plants;

(d) application of technology to rural development with projects on, inter alia, clay bricks, lime kilns, plastic products for agriculture;

(e) technologies for alternative sources of energy with projects on, inter alia, bio-mass energy, pyrolysis of organic wastes;

(f) national and international policies related to appropriate industrial technology (development of indigenous technology, evaluation and selection of technology);

(g) institutional infrastructure for appropriate industrial technology (assistance of technological institutions in developing countries);

(h) training programmes in appropriate technology.

At the moment[204] it is difficult to judge to what extend this programme will be implemented.[205]

203. The action programme followed the meeting of a workshop on the subject, organized in Oct. 1976 in cooperation with the Dutch Government. One of the important basic documents is Bos (1975).

204. On June 24, 1977 the decision of the Industrial Development Board was published. The Board 'welcomes the report', but considers that 'the report provides a framework primarily for action and funding by Governments, national and international organisations .... the priorities accorded the specific projects listed in the report will therefore be determined by the interest and action of such entities ...' As to the activities of UNIDO itself the Board only 'Considers that aspects of appropriate technology should be introduced into the UNIDO sectoral consultations.' Yes, why not.

3.1.4 International Labour Organisation. The ILO is, by its nature, interested in the labour aspect of production systems.[206] Hence, it has been one of the first established organisations to stress the necessity of giving 'a higher priority to expanding the number of income-earning opportunities as a means of ensuring a better distribution of the fruits of growth.' The "World Employment Programme",[207] launched in 1969, tries to integrate growth, employment, income distribution and fuller social participation.[208] At the moment there are 301 projects in progress covering all possible aspects of employment policies.[209] The book of Sen (1975) on "Employment, Technology and Development", to which I have already referred a number of times in chapter 2, has been commissioned by the ILO. The empirical studies gathered in Bhalla (1975), on which a considerable part of section 1.6.3 is based, is among the major results of the Programme.[210]

205. I am not optimistic. For example: Although the Lima-conference has induced a process of change in UNIDO a considerable output is still based on obsolete philosophy. For example, as a result of the Lima declaration, a consultation meeting on the fertilizer industry was held in January 1977 . The report (UNIDO, 1977a) contains virtually no information on aspects such as scale of production, while better use of organic wastes, or the existence of patents, are not mentioned at all. The only "critical" remark made is the well-known fact that 'the efficiency levels and the capacity utilization were below desired levels'. Recommendations are of the type 'that international financing agencies should lend their support to well-conceived projects', while 'fertilizer plants set up in developing countries must be so planned that they would be viable'.
206. The ILO was established in 1919. It is governed by politicians, employers and workers (three-partition).
207. 'The over-all objective of the World Employment Programme (WEP) is to assist member States in the elaboration of specific guidelines that will enable national political decision-makers and planners to reduce employment and underemployment by accelerating the creation of productive income-earning opportunities, and to help them in devising and implementing the appropriate policies and measures for giving effect to such guidelines.' (ILO, 1976b, p.6.)
208. When the Programme started it was basicly concerned with the underutilization, low productivity, and often low-income of the labour force, as well as the problem of educated unemployment. '... the experience gathered during the early years of the implementation of the programme has demonstrated the utmost importance of a number of additional specific issues. They are: (a) the need to directly attack poverty; the "trickle down" effect... does not seem to operate quickly enough... (b) the importance of taking into account the international context; ... (c) the importance of the employment situation and policies in the industrial countries.' (ILO, 1976b, p. 7.)

In 1976 the ILO philosophy was further specified on the "tripartite World Conference on Employment, Income Distribution and Social Progress" at which the "basic needs" concept was formulated.[211]

'Strategies and national development plans and policies should include explicitly as a priority objective the promotion of employment and the satisfaction of the basic needs of each country's population... Basic needs, as understood in this Programme of Action, include two elements. First, they include certain minimum requirements of a family for private consumption, adequate food, shelter and clothing as well as certain household equipment and furniture. Second they include essential services provided by and for the community at large ... A basic needs-oriented policy implies the participation of the people in making the decisions which affect them through organisations of their own choice.'[212]

3.1.5 Organisation for Economic Co-operation and Development. The

209. The 301 studies (see ILO, 1976b) cover the evaluation of development models, conceptual and measurement problems of labour, agricultural productivity and employment, the industrial case studies such as those in Bhalla (1975), a large number of projects on road construction and housing in various countries, 43 projects on income distribution, 69 demographic studies (population growth, migration), 35 on the evaluation of rural development, 28 on urban development, 34 on education, and 7 on multinationals. To me, by far the major importance of this programme is the attention given to making empirical estimates of employment and distribution effects of alternative production systems.
210. Among others the following are studies commissioned by the ILO: Delle Valle (1975), Cooper et al. (1975), Stewart (1975), Pack (1975), Boon (1975), Bhalla (1975), Baron (1975). Cf. notes 91, 92, 96, 97, and 100.
211. Although "employment", "poverty", and "basic needs" are closely related when contrasted with economic growth (cf. section 2.1) the indicators to measure progress are different. Following Lisk (1977) one can distinguish four categories of development strategies: (a) growth oriented (maximalization GNP, increase in the rate of physical capital formation, modern sector); (b) employment oriented (increase in the level of productive employment, informal and traditional sectors); (c) poverty oriented (raising income below poverty line, unorganized sectors); (d) basic-needs oriented (satisfaction of subsistence level needs).
212. See ILO (1976a, 1977). Kuzmin (1977), an ILO staff-member, states that the 'basic-needs concept is essentially ... a strategy of integrated development', its main outlines being: 'the creation of new production linkages, including inter-industrial and intersectoral ones; the maximum involvement of traditional societies in economic activity; through examination of the dynamics of different social groups with a view to securing their fuller participation in socio-economic activities; and enlargement of the economic functions of the State".

"Development Assistance Committee" (DAC) of the OECD 'endeavours to ensure that aid is put to the best use'. The (development) aid concerned is that of the OECD members, the 16 richest countries. They provide more than 80% of aid either in bilateral programmes (more than 50%) or via other agencies. 'The OECD Development Centre was established with a view to creating a link with non-member countries in the process of development.' Apart from serving as a centre of exchange of information it carries out a considerable research programme.

The external effect of the Centre is based mainly on the conferences it organises. Many references in this report are to contributions to the conferences on "Choice and Adaptation of Technology in Developing Countries" (1972), "The Role of Small Scale Industries in Transfer of Technology" (1973), "Development Projects Designed to Reach the Lowest Income Groups" (1974a), "Low Cost Technology and Rural Industrialisation" (1974c).

In 1976 a completely new research program was established - partly against the wish of the staff of the centre[213] - on "technology and industrialisation", now concentrating on rural development and import substitution production systems, strongly reducing the interest in export industries.[214]

3.1.6 The United States of America. By the US Agency for International Development (AID) various reports on "appropriate technology" have been commissioned from 1972 onwards. This resulted in 1976 in a "Proposal for a Program in Appropriate Technology".[215] Formally the proposal was the result of a decision in 1975 of the House Committee on International Relations on 'a new section 107 of the Foreign Assistance Act of 1961 to authorise the Agency for International De-

213. The Centre itself tends to concentrate too much on the interests of LDCs, according to OECD members, although 'The Centre has a special autonomous status within OECD which fully ensures its scientific objectivity ...' Research proposals on export industries for LDCs are systematically turned down if there is a danger of increased competition for industries based in OECD countries. (An example is pulp, paper, and timber products from tropical hardwood.)

214. About 60 projects are in progress now, covering subjects like molasses and industrial alcohol; alternative energy strategies; role of engineering firms in international transfer of technology; post-harvest problems; engineering, transfer and adaption of technology.

velopment (AID) to support an expanded and coordinated private effort to promote the development and dissemination of technologies appropriate for developing countries.'

In the "Foreword" to the proposal chairman T.S. Morgan of the House Committee says that: 'The committee strongly believes that appropriate, or intermediate, technology, through its favorable impact on employment and self-reliance, can be an important means of implementing a development strategy which emphasises participation and concentrates on improving the lives of the poor majority of people in the developing world.' Section 107 of the above mentioned law makes available 20 million dollars for appropriate activities during 1976-1978. It remains to be seen whether this will grow in the future. At the end of 1976 an

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215. US-AID (1976), reprinted 1977:
'The experience of more than a quarter century of development assistance programs overseas has demonstrated that much of the technology used in the United States and other industrialized countries is not well suited to the economies of developing countries....
If the poor are to participate in development, as envisioned by the reforms enacted in the Foreign Assistance Act of 1973 and by this bill, they must have access to tools and machines that are suited to labor-intensive production methods and to their small farms, small business, and small incomes. They must have access to technology which is neither so primitive that it offers no escape from low production and low income nor so highly sophisticated that it is out of reach for poor people and ultimately uneconomic for poor countries - in short, intermediate technology....
This is not to say that capital-intensive technologies are invariably inappropriate in developing countries. In some circumstances, efficient, labor-intensive technologies may not exist (e.g. petro-chemical industries) or competitiveness in export markets may require precision machine-made products. Developing countries require a mix of technologies. The problem in many developing countries, however, is that the current mixture is felt to be over-rich in a capital-intensive direction to the detriment of both employment and output growth....
Among the objectives of such an increased effort in intermediate technology are the following: (1) To promote the development and dissemination of technologies appropriate for developing countries, particularly in the areas of agriculture and rural development , small business enterprise, and energy; (2) To identify, design, and adapt from existing designs, appropriately scaled, labor-intensive technology, and policies and institutions directly rated to their use; (3) To formulate policies and techniques to facilitate the organization of new small business; (4) To engage in field testing of intermediate technology; (5) To establish and maintian an information center for the collection and dissemination of information on intermediate technology; and (6) To support expansion and coordination of developing country efforts in the field.'

independent, non-profit, private organisation "Appropriate Technology International" was established to carry out section 107.

3.1.7 The Dutch Government. In the Netherlands interest in appropriate production systems also started around 1972,[216] but did not gain any momentum until 1975. In 1975 a symposium on the "New International Economic Order" was held; however, the concept of "appropriateness" was not mentioned there. But it was mentioned in all variations at the NUFFIC conference on "Science and Technology for Developing Countries" held at the end of the year.[217] Also in 1975 a "think-tank" produced a report on appropriate technology for the Ministry of Foreign Affairs and various smaller-scale seminars and lectures were held, in particular at the universities of technology.[218] In 1976 a semi-international conference was organised by TOOL, the term "socially appropriate technology" started to appear in government papers,[219] and a series of 15 short articles on appropriate technology was published in the establishment journal *De Ingenieur*.

216. At the Twente University of Technology a report on technical sciences and the third world was published (THT, 1972), in which "the new look" was apparent. The proposal to found TOOL, an organization meant to be roughly similar to ITDG, was made in 1972 (see on TOOL chapter 4).
217. See Dutch Government (1975), NUFFIC (1975a, 1975b). NUFFIC is engaged in organizing international courses and in coordinating cooperation projects between Dutch and overseas universities. The participants of the conference were not able to come to any conclusions.
218. See Korthals Altes (1975), KIT (1975a, 1975b). The think-tank had as members persons from KIT (Royal Tropical Institute), TOOL, TNO (government organization for applied research), DITH (dept. of int. techn. assistance of the ministry of foreign affairs), and a sanitary engineering firm (Dwars, Heederik and Verhey).
219. Socially appropriate technology comes under the concept of "development-relevant-research" which is also concerned with those changes in the economic and social structure that would enhance self-reliance and development of the poorest people (Dutch Government, 1976). 'Ontwikkelingsrelevant onderzoek is ook het onderzoek dat bijdraagt aan de bevordering van het zogenaamde "self-reliance" beleid van de ontwikkelingslanden. Dergelijk onderzoek kan zowel gaan in de richting van toegepast onderzoek voor de ontwikkeling van sociaal-aangepaste technologie als het vastleggen, verspreiden en analyseren van die elementen van het sociaal-culturele milieu van de ontwikkelingslanden die belangrijk zijn voor het proces dat "self-reliance" is.... Als enkele hoofdterreinen van onderzoek kunnen genoemd worden de verbetering van de landbouw, de rurale watervoorziening en bijbehorende gezondheidstechnieken, de technologie waaronder de aangepaste technologie en het vraagstuk van de energiebehoeften van de arme landen.' (Dutch Government, 1976a, p. 70f).

The Dutch Government have played a major role in reorientating the research of the OECD Development Centre to rural areas and in the adoption and implementation of the relevant resolutions at the Lima conference of UNIDO.

3.1.8 Evaluatory remarks. All important organisations are now in favour of appropriate production systems, but what does this mean? Not Very Much. There is mainly one technical problem and one fundamental problem. The technical problem is that processes of change go slowly. The policies have changed, but what about the people who have to implement the now different policies? They will usually keep their personal opinions. This is a kind of structural constraint to implementing policies which will die out only very slowly, if at all.

The fundamental problem is that what is appropriate is conceived differently by groups with different interests. The ruling classes in LDCs may not be that interested in a basic-needs strategy. The ruling classes in industrialised countries may not be so very interested in giving up the idea of intellectual property.

Books have been and will be written on these two problems. I shall not analyse them any further.

3.2 The appropriate mixture

3.2.1 The production vs employment dilemma. That is, is maximum production through the use of the most modern production systems or the fullest utilization of available resources the best path to economic growth ?[220] Although the trend favouring labour-intensive techniques is at the moment increasing significantly, it should be realised that

220. It is not difficult to provide theoretical solutions: 'In the normal case, when the modern technology is more capital-using, the proper strategy is to eliminate unemployment first and only then to attend to the shift of resources to the modern sector. The elimination of unemployment requires channeling of all gross saving to the old technology, temporarily reducing the size of the modern sector. There is nevertheless no conflict of objectives. The strategy that eliminates unemployment most rapidly also maximizes the growth of net income and consumption. Once full employment is achieved, it can be maintained while the relative allocation of resources shifts in favor of the modern sector. But none of the interim investment in old-technology capital is lost; the older sector grows absolutely even while it declines relatively.' (Tobin, 1974.)

the debate is as old as development theory, and in fact the trend favouring capital-intensive techniques emerged at a chronologically later stage.[221]

The discussion is complicated by the fact that aspects of labour and capital are usually not separated from that of scale. For many writers, labour-intensive implies small-scale, and capital-intensive implies large-scale. In this subsection I summarise the macroeconomic arguments regarding both.[222] ThereafterI shall deal separately with the case for large-scale labour-intensive and the case for small-scale (not necessarily labour-intensive).

(a) Growth factors. Labour-intensive production systems ("L-systems") are less efficient in terms of labour productivity and the consumption ratio will be higher due to distribution of income. Usually L-systems need more working capital. The use of capital-intensive production systems ("C-systems") will result in greater savings and investment per unit of output, hence a more rapid growth. Therefore short run maximisation of employment does not necessarily coincide with long run objectives.[223] Against this it is argued that generating more jobs from the capital available will spark more demand for marketable products.[224]

(b) Market. Many C-systems are not economically divisible and can-

221. 'If investment funds are limited, the wise policy, in the absence of special considerations, would be to undertake first those investments having a high value of annual product relative to the investment necessary to bring them into existence.' (Buchanan, 1945, p. 24.) See also Kahn (1951): 'China will and should in general specialize in industries and use techniques requiring a lower capital: labour ratio than the United States.' It is only from about 1955 onwards that the "rate of return" argument became dominant.

222. Arguments have been summarized by, among many others, UNIDO (1964), Stewart (1972), Morawetz (1974), White (1976), Askin (1977).

223. Schumacher argues against this that it assumes a too abstract model of dynamic growth. Even if total output would be lower he thinks that man's employment will induce the many immaterial conditions that are necessary for dynamic growth to come about. In taking employment as the prime objective, two things have to be kept in mind: (a) there should be some output that raises the national income, and (b) people working always need some capital goods: only if the latter can be made using idle resources (natural and human) is the opportunity cost of the employment zero (Stewart, 1972).

224. The discussions on the effect of industrialization on income distribution are conflicting. Tokman (1975) argues that the effect is only positive when L-systems are used.

not produce solely for a small domestic market; whereas the international market requires quality control and precision.

(c) Skills. L-systems require more complex management skills. Abundant unskilled labour may be useless, not only for C-systems.

(d) Integration. L-systems, assumed to be small-scale, can make better use of traditional economic activities and raw materials; they will adopt themselves more easily to the local environment; they will develop better linkages with backward areas; and finally they can cater better for regional markets. C-systems generate so-called down-stream employment and skills, and therefore give a better basis for technical innovation and development.[225]

(e) Culture. C-systems have more prestige-value. L-systems tend to be static and therefore inhibit a dynamic development.[226]

3.2.2 Employment policies.[227] It will be clear from the previous chapter that expansion of industrial manufacturing alone cannot be expected to solve the employment problem.[228] In the traditional labour-intensive school, policies will concentrate on "letting factor endowments speak", and hence will set out to change all distortions in the value of (social) factor prices as mentioned in section 1.6. But

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225. 'Capital saving innovation is difficult without an indigenous machine tool industry - and with a market of critical minimum size.' (Rosenberg 1963.)
226. 'Labour intensive techniques necessitate large numbers of unskilled labourers and quasi-entrepreneurial intermediaries who may later resist technological progress.' (Phillips, 1963.)
227. See section 1.5.3 and 2.2.3 on the concept of employment. 'The view that in developing economies labour should be valued not at its market price but at its correct "shadow price" has been expressed with increasing frequency in recent years and there would now seem to be a remarkable degree of agreement on this proposition. However, it seems, alas, to be the case that this unanimity about the need for using shadow prices is not altogether matched by an agreement on the *meaning* of shadow prices.' (Sen, 1975.)
228. The empirical data on this question are scarce and sensitive to disputable assumptions needed to obtain them. However, I think a reasonable order of magnitude estimate is that -all other factors being equal- substitution of L-systems for C-systems would increase employment in industry with 20 to 50% in 10 years. That is significant in terms of industrial employment, but almost negligible when compared with the absolute number of unemployed people or those working in agricultural production.

if only L-systems are chosen to produce for demand as observed, one will never overtake the growth in unemployment.

More convincing is the argument for a rapid redistribution of income and reallocation of investment funds to production systems producing food and other basic consumer goods. A natural side effect of such a policy is reduced imports, because there is less money to be spent on luxury goods. Whether such a policy can be implemented I shall not venture to discuss.

In employment policies it may be useful to distinguish the following categories of production systems: agriculture and postharvest technology, rural industries, small-scale industries, public works, and manufacturing industry. In the literature L-systems usually comprise only the latter three categories. I shall not discuss the case for L-systems concerned with construction works, i e making roads, dams, houses and the building materials needed.

When the case for large- and medium scale L-systems is made, chemical industries, in particular the petrochemical sector, do not provide much solace.[229] I think that for chemical production systems one should concentrate on the choice of product and the scale of production:[230] labour-intensity can then be dealt with as a dependent variable. If it is given that cement or sugar or fertilizer or petrol have to be produced on a large scale and meet certain product specifications, it is not worthwile to engage in time consuming studies how to do that in the most labour-intensive way, - in particular that is so if no time has been spent on considering alternative scales and product

229. Studies on the employment aspect of chemical industries include Tokman (1974, 1975), Agarwal (1976), Roemer et al. (1975). Roemer et al is illustrative: They analyzed the available choice in "L-systems" for Tanzania. For sugar, fertilizers, petroleum, and pharmaceuticals there was virtually no choice. For leather and cement there was a marginal choice. And there was a reasonable choice for food processing, wood products and soap, *but*, by choosing the most L-package, employment would be only 35% higher of a total employment that was itself negligible relative to the country's work force.

230. Already in the seminar on the development of basic chemical and allied industries in Asia and the Far East, held in 1962, 'Special attention has been given to those industries which require comparatively small investment and employ fairly simple technology.' (ECAFE, 1963.) Such phrases are ambiguous, because it is not clear whether the choice is between products or between processes for a given product.

specifications. Of course, it does not follow that the choice does not matter: it does not matter relative to an employment policy; there are other reasons to minimise on capital relative to value added.

3.2.3 The case for multinationals. 'There are several limited capability, environmental dependent cooling systems that because of their simplicity, low cost, and low energy requirements are attractive despite marginal performance characteristics; ... construction of walk-in coolers using locally available materials should be developed... Contingent on the development of low cost solar collectors or the application of diesel generators to community power generation, absorption cycle systems capable of operation at low generator temperatures should be considered for development.' This quotation is not from a recent ITDG publication, but from a report of General Electric, published in 1962. Those people who are, for understandable reasons, not so much in favour of multinationals, often do not realise that multinationals excert power because they know how to do things, and not simply because they have the power. Idealistic tinkerers engage in designing "refrigeration-cooling systems for rural communities in developing countries" (the title of the above mentioned report), or production systems of soap, cementitious materials, sugar, etcetera, without awareness of the fact that there are other institutions in the world who are much more capable of doing so.[231] Even the East African Industrial Research Organisation[232] cannot compete with Lever Brothers if it comes to making soap from local materials.[233]

In OECD (1972) a usefull distinction is made in the issues that are important about multinationals:

(a) whether they perform better or worse than the alternatives in adapting technology to LDC conditions, especially factor endowments

(b) whether they distort consumption patterns and the choice of products on offer in LDCs;

231. Directors of multinationals keep saying that: "Waar het gaat om technische ontwikkelingsprojecten is het evident dat de benodigde experts in de allereerste plaats bij de Westerse industriële ondernemingen zijn te vinden." (Boldingh and Goudswaard, 1974.) Moreover, it is true. The question is *what* they choose to do. On transfer of technology and production systems by multinationals see: Germidis (1975), Velthuis (1977), Vaitos (1970), Langdon (1975).

232. See on this organization section 4.3.

(c) how well they promote (or inhibit) linkage effects within LDC economies and LDC capacities to innovate.

It is the issues (b) and (c) that create problems together with the support multinationals give to the formation of local elites. In a sense the fact that multinationals perform better with respect to (a) only adds to the problem, because it becomes more difficult to get around them if one is concerned with (b) and (c). The case for multinationals is always based on (a), and I would like to bang the drum as loudly as possible to stress that, on the level of (a), it is an extremely good case: Multinationals are most active in the so-called "international redistribution of labour";[234] multinational subsidiaries are more labour-intensive than indigenous companies;[235] multinationals are the first to adapt their products to local markets and their pro-

233. The soap production in Kenya would lend itself for a most interesting thesis. The student can start with studying EAIRO (1970, 1975), Langdon (1975) and Pack (1976a). Langdon (1975) describes in detail how in Kenya the hand-made soaps have been outruled and local firms forced to mechanize due to publicity campaigns of foreign firms, whereas the hand-made soap is technically of a better quality. An even more interesting thesis could be written by somebody who had access to the Unilever files. They are very proud of how good they are adapting their processes to local markets and materials. For example Velthuis (1977) describes how, in India, they developed processes so as not to use edible oils for soap production, designed simple low-energy centrifuges (which are more labour- and space-intensive), etcetera (see also note 103). It would, however, be useful to analyze this in a historical context. Taking into account, for example, that import of soap started in 1880 and production in 1934.

234. Ziemek (1972) reports of a survey carried out by a German consulting firm (the *Planungsgruppe Ritter*) on labour-intensive production systems that could easily be transferred overseas; 400 German firms were covered, who had already 250 collaborations with 48 developing countries producing 200 labour-intensive products and product groups. Transferable product groups include fine ceramics, plastics and leather processing, paper and printing. Probably, the multinationals are hampered more by trade restrictions than anything else in carrying out these programmes.

235. 'In tegenstelling tot de industrielanden - waar het zwaartepunt van de industriële activiteiten steeds meer komt te liggen op kapitaalintensieve fabrikages van technisch ingewikkelde produkten voor grote marktgebieden - worden in de ontwikkelingslanden in het algemeen betrekkelijk kleine series eenvoudige produkten gemaakt in arbeidsintensieve bedrijven.' (Van Riemsdijk, president Philips, 1977.) See Velthuis (1977) and note 103 for examples of adaptations to local factors.

cesses to local raw materials;[236] multinationals are the only institutions that have experience in scaling down plants and production lines. On (b) and (c) see section 2.3 and 2.4.

3.2.4 The case for small-scale. It is generally agreed that 'small enterprises are a vital sector of a country's economy because they represent a major share of national production and employment',[237] and at least in name all governments have established some service to give practical advice on techno-economical and managerial problems. Nevertheless, there is also the general opinion that small-scale enterprises are an inevitably backward and lagging part of the economy; they 'are often ill-equipped and poorly managed and suffer from low productivity and unsatisfactory product quality' and hence policies concentrate - with little succes - on solving these problems. The literature on the subject is enormous[238] and deals with how to go about the stimulation of entrepreneurship[239] and managerial practices, financing and training facilities, trouble shooting and improvement of

236. For empirical studies showing that multinationals make substantial L/C substitutions see White (1976) for the literature up to 1975 (16 references). Further Agarwal (1976), whose findings for India show that foreign firms are more C-intensive than domestic ones, but I think that is caused by differencesin products (on which Agarwal gives no information). Morley and Smith (1977) report substantial modifications in Brazil, and show convincingly that the modifications are not induced by differences in prices but by differences in scale.
237. Bass (1976), UNIDO (1969d), Vepa (1971).
238. The literature on small-scale enterprises is enormous. In ICSSD (1965) more than 200 references are given on Japan and the same number on India. Many conferences are held on this subject; important ones being ECLA (1967) and OECD (1973) (see also references in UNIDO (1969d). Most literature is abstract reasoning about how to encourage and help small-scale industries. Vepa (1971) gives a useful summary of the existing institutional structures concerned with these matters in virtually all countries. See Behari (1975) on recent developments in India. Empirical studies on what is actually happening to small-scale and cottage industries in various countries were rare, but are now appearing in increasing numbers. See Schädler(1970) and Müller (1974) on Tanzania, Kristensen (1974) on Kenya, Chuta and Liedholm (1975) on Sierra Leona, Sigurdson (1975) on China.
239. Entrepreneurship is 'an ability to assemble or reassemble from what is available to one a new kind of activity, to reinterprete the meaning of things and fit them together in new ways. It is also a very concrete kind of imagination, alert to the specific opportunities of a particular place at a particular time, improvising for what lies to hand.' (Harris, 1968.)

production-processes, technical extension services, industrial estates, providing techno-economic evaluations, etcetera, etcetera.[240]

Analysis of the non-succes of the small-scale sector to raise productivity, integrate the rural into the national economy, modernise traditional production systems, tend to concentrate on missing links[241] (entrepreneurs, capital,[242] knowledge). All over the world extension services and similar have been working in these areas for many years, yet these obviously relevant policies have ended in disappointment.[243] A more correct analysis is to look behind the official policies. On the one hand, I think, it is beyond dispute that a number of products cannot normally be made on a small-scale, unless production system and market are completely inaccessible from other markets. This is shown

240. UNIDO (1969d), Ntim (1974), Bass (1976), UNIDO (1969e), ECLA (1967), etcetera. With slight variations of the following it is said again and again that small-scale enterprises 'are confronted with the following problems: - lack of basic technological knowledge; - lack of purchasing power; - lack of capital to establish and operate business; - inability to implement research findings; - insufficient facilities for repair and maintenance; - inadequate facilities for technological training; - scarcity of entrepreneurial knowledge and skills; - insufficient information on technologies which have been used successfully elsewhere in Africa and abroad; - insufficient information on available local materials. To contribute to the solution of these problems it was recommended: (a) to compile and disseminate information on the properties of materials available locally, including design data on those materials; (b) that the developing countries create local centres to promote small-scale industries. The functions of these centres should include the dissemination of research results, on-the-job training programmes, financing the introduction of new technologies, training in basic business methods and product design.' (DSE, 1972, p. 15.)
241. It is a well-known (prejudiced) fact that African family life (or culture X) inhibits the individualism typically associated with the entrepreneur. As far as I know there is no intercultural basis for that. Firstly, it may be argued that the characteristics of a successful entrepreneur will depend on the environment in which he has to operate, and secondly (see Harris, 1968) development of local entrepreneurship is hampered by social isolation from the economy of which he is a part. For example, an African businessman probably still has a European bank-manager and an Asian supplier.
242. Tinbergen stressed already in 1958 that for a healthy development the small-scale industry should invest more.
243. Analysis of these failures have stressed that extension services fail because of high qualification demanded of staff. See references on Israel, Turkey, Ghana, Nigeria in Harper (1974). Also 'planners and practitioners of arrangements in support of the small industries have most often to formulate their own strategies' (Müller, 1974); hence any small-scale production system is considered as good as any other.

in particular in the case of China.[244] On the other hand, I think, India illustrates the other extreme. Although 'The village handicrafts and small industries in India have been accorded a very high priority in the programmes of the economic growth particularly from the standpoint of social equity',[245] this has no bearing on the actual situation. The procedure is roughly as follows: One chooses for modern large scale C-systems, and designsand implements policies to help their development as much as possible. *Then,* one discovers that there is a problem left, namely employment. This problem has to be solved by the small-scale industries and some marginal measures are taken, preferably financed from special taxes on small enterprises, to help them *in an environment that has been adjusted as much as possible to accommodate the large-scale C-systems.*

The case for small-scale is a good one,[246] if it is interpreted as providing favourable boundary conditions for the development of small-scale production systems. This does not, however, imply that small-scale is good by definition. For example, if, in a given technological

244. Sigurdson (1975) estimates that most of China's 50,000 communes have their own grain-milling and oil-pressing facilities. Small process industries (iron and steel, cement, fertilizer) operate on county level, if (i) raw materials are available, (ii) there is local demand, (iii) there is no easy supply from elsewhere. 'The diseconomies of small-scale production are such for certain process industries that local enterprises can only operate under very favourable conditions, or for limited periods until economic development removes constraints such as transportation bottlenecks, foreign exchange limitations, etc..... The encouragement of efficient and productive small-scale industries in rural as well as in urban areas has never been presented as an alternative to the development of medium- and large-scale enterprises....' For small-scale process industries I think the correct policy statement is: *If* there is local demand, idle labour, resources, and some capital available *then* starting a production system makes an important direct and even more so indirect contribution to development - even if it would have only a short live time. (It follows, that developing useful technology is relevant.)

245. Behari (1975). Following Gandhi's programme of rural reconstruction these type of phrases occur in all official papers. However: 'This Gandhian ideal, I am afraid, has been honoured more in its breach than in its observance during the last 25 years.' (Subramaniam, 1975.) Hewavitharana (1971) expresses a similar opinion as to Sri Lanka. In the next chapter some information is given on the various bodies in India (and other countries) serving the small-scale development. See for an analysis of Indian policy in particular Gadgil (1964) and for the history Gadgil (1942).

context, small-scale production has not only a higher labour to output ratio, but also a higher capital to output ratio, than - all factors being equal - there is no simple rationalisation for choosing small-scale.[247]

3.2.5 The case for rural development. The concept ot rural development is not difficult; it is defined 'as improving living standards of the mass of the low income population residing in rural areas and making the process of their development self-sustaining.'[248] The "intermediate technology" movement is most closely related to the idea of rural development and has been active in the process of increasing interest in rural development.[249] Any rural development should take into account the following features: relative priority of allocation of re-

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246. For example because 'I have the conviction that modern small-scale industries could be developed by replacing the primitive technology of ditional craftsmen with an intermediate technology. In this way, tra- modernization could be effected without the high social costs resulting from a total disruption of existing institutions. Of course, the transition from primitive technology to intermediate technology results in increasing centralization...' (Tadess (1976), head Small-Scale Industries and Handicrafts Dept., Ministry of Commerce and Industry of Ethiopia.)
247. See however note 223. Examples could be the hand-loom in Sri Lanka (Hewavitharana, 1971) and handpounding of rice in India (Bhalla, 1965). Cf. note 67. The main reason for the inefficiency of the small-scale techniques is that they have a low number of operation hours, typical for cottage industries. The best rational solution is, I think, to introduce the economic concept of "the costs of income redistribution", in the same way as the concept of "the costs of economic growth" was introduced.
248. Lele (1974). Typical objectives of rural development programmes are: increase in output, reduce unemployment, improve public services, increase decentralized responsibility (IDS Nairobi, 1972). Also: 'The primary purposes for introducing appropriate technology for rural development are (a) to reinforce indigenous technology so as to improve the production of the necessities of life; (b) to introduce measures for the improvement of public health through health education and sanitation; (c) to improve the production of agricultural and handicraft products over and above subsistence requirements, which can be exchanged for cash with outside communities; (d) to reduce the drudgery and hard manual work in production activities, and to provide additional leisure.' (DSE, 1972.)
249. 'The key strategy in Kenya's current Development Plan 1970-1974 is to direct an increasing share of the total resources available to the nation towards the rural areas.' (Oyiro-Agoro, in: DSE, 1972.) Similar phrases occur in all development and five year plans. Consider however the penultimate paragraph of the last subsection.

resource to rural development; establisment of the appropriate institutional agents of change; making the process self-sustaining (this means "involving", not only "reaching".) For rural development the following production systems can be distinguished:[250]

(a) Straight agriculture, animal husbandry, fisheries , forestry and bee-keeping. These areas are outside the scope of this report. In view of the goal of self-sustainment, emphasis should be on trying to grow everything that is needed for one's own balanced diet and raw materials for the other primary necessities of life. Secondly there should be an emphasis on producing surplus for village industries rather than for factories.[251] Thirdly, the objective of increasing yields should not outrule the employment aspect.[252]

(b) Post-harvest technology. Under this heading should come all storage and preservation problems as well as all those unit operations, such as drying, milling, extracting, boiling, that have to be executed before any long period of storage or transport.[253] Until recently these aspects of increasing output, as distinct from direct yield, have been quite neglected.

(c) Food processing. Most of the unit operations are the same as under (b): milling, boiling. The only reason to separate it from (b) is that time and place are less critical and that often different people are involved when the same "harvest" passes from phase (b) to (c). Family food processing, i e making the meal, is done by women and in recent years there has been an enormous boom in studies on the role of women in rural development[254].

(d) Village mechanisation. 'Millions of people have missed the chance to become self-reliant in mechanisation matters, because mechanisation was brought to them ready made. For example many communities never made their own wheel, or even used a wheel before a visiting section of a different culture suddenly appeared with a wheelbarrow, or a waggon, or a bicycle. Therefore those people were intro-

250. See, for example, Gadgil (1964), UN (1974c), Behari (1974b).
251. For example, the type of sugarcane or cotton grown for factories, is different from that most suitable for local processing.
252. Griffin (1976) illustrates how modern measures like land concentration may lead to less efficient land use and more surplus labour.
253. Most of these post-harvest unit operations will be discussed in chapter 5.

duced to the wheel as something which must be bought, rather than made for oneself.'[255] At least village people should be capable of maintaining and repairing their equipment. In the end the tools as input for agriculture should be produced locally.[256]

(e) Rural building and construction. This covers housing, storage places, irrigation schemes, and simple roads and bridges to get access to regional markets.

(f) Artisans and handicrafts. Taken in a wider sense this includes (d) and (g); in a narrow sense this category is restricted to decorative goods. It is typical for a process of development that the number of craftsmen decreases,because manufacturing industries take over.[257] There is widespread belief that the rural industries are so primitive and old-fashioned that one can never hope to modernize them. Even with respect to the "original" handicrafts which (could) produce for export many writers are sceptical.[258]

(g) Consumer goods. Under this heading comes clothing, footwear, ropemaking, pottery, and similar. In many countries, in particular India, many studies have been carried out on the prospect of traditional spinning, weaving, and tanning.

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254. A bibliography issued at the end of 1976 (Buvinic, 1976) quotes 400 sources, most of them later than 1970. Programmes for agricultural development were often only directed at men, although in many areas women are at least as important in food production. 'As a result of the attitudes of the extension service, the gap between the labour productivity of men and women thus continues to widen. Men are taught to apply modern methods in the cultivation of a given crop, while women continue to use traditional methods in the cultivation of the same crop, thus getting much less out of their efforts than men.' (Boserup, 1970, p. 55f.) As with land reform one has to be careful in introducing labour saving techniques to reduce drudgery and hard work when there is nothing else to do. It has been estimated that introducing an appropriate rice huller in Indonesia substituted 125 million women days of labour per year - deriving many women of the only income they had. See for example Pala (1976) on cultural factors involved in introducing new techniques to be used by women.
255. Macpherson (1975), which is one of the better "handbooks of village mechanization".
256. 'The thought that mechanization of agricultural production means only large tractors and associated equipment is incorrect in most cases, particularly for densely populated less developed countries.' (Esmay and Hall, 1973.)
257. See for example Karsten (1972).

(h) Subcontracting for urban manufacturers. This could be clothmaking, but usually one thinks of the Chinese and Japanese examples of rural electronic industries and similar.

Evaluations of rural development programmes have shown that there is a long way to go before there is any succesful change. Large programmes did not start until the mid 60s, and large-scale evaluation studies are only just appearing. Nevertheless the recurrent conclusions are already widely known, mainly based on the older anecdotal evidence. They include:[259] changes have little appeal; farmers are irrational and over-fearful (perhaps past experience has given them good reason to be so); there is widespread bureaucratic obstruction by civil servants and elites, whereas (foreign) planners miss any idea of the "microcause-large effect" aspects of their grand schemes; in spite of the nice plans, in fact, the rural areas are still exploited by

258. Ho and Huddle (1972) analyzed world markets and labour-intensity of handicrafts and concluded that much can be made of this. However 'The handicraft industry is often recommended for developmental attention because it is labor-intensive. Products of the handicraft industry either fall in the decorative category which are usually exported, or village-craft utility products, which are used by the poorer segment of the population. Decorative luxury products have limited potential in the domestic markets. Demands for village-craft utility products will decline as standards of living rise and products of a higher technological order find their way into the developing countries' market.' (Khan, 1973.) That is to say, if all earthware is substituted by plastic and metal containers, as it is, quite some "decorative" earthware has to be produced. Original handicrafts may make a contribution to gaining foreign exchange and may support tourism -if there is any good in that- but does not provide so much employment.

259. See Michel and Ochel (1975); Huizer (1975) on Latin America; Vail (1974) and Amey (1974) on Tanzania; IDS-Nairobi (1972) and Lele (1974) on Kenya. See also references on India in note 238. DSE (1972, pp. 11-15) gives a typical example of "recommendations for rural development". It should be stressed that also in Tanzania, a country often quoted for its appropriate governement policy, 'Many villages are in a state of deadlock' (Macpherson, 1975, p. 225), 'extension officers are not in favour of low-cost tools' (Vail, 1974), and 'the terms of trade have declined severely against the rural sector ... the average peasant has suffered greater losses in welfare than either the urban minimum wage earner or the middle-income civil servant.' (Amey, 1976, p. 47.) But, of course, it is extremely difficult to draw any general conclusions. Lele (1974) in a review of 13 programmes in Africa is rather optimistic about the prospects when techniques are suitably adapted to the local environment: 'Where considerable effort has been made to adapt technology to suit small farm conditions, as in the K.T.D.A. in Kenya or CADU in Ethiopia, the response of small farmers to innovations has been

the urban areas.

3.2.6 The appropriate mixture. It will come as no surprise to the reader that the compromise between these different approaches is simply that one should choose the appropriate package of production systems.[260] As was briefly indicated in section 1.2 and came out clearly in section 3.1 the "appropriate technology" movement has now been encapsulated by giving it its appropriate place in the package.

I think it is true that there is no development without any capital-intensive large-scale project. I think it is true that there are quite a number of obsolete non-feasible small-scale production systems. However, those talking about appropriate mixtures, have a certain bias, as is apparent - for those who can see - in the following quotation of the director of the Tropical Products Institute:

'A recent, distinguished spokesman made an appeal which generally supports this approach. Professor N. Hasam, the Indian Minister of Education, Social Affairs and Culture said at the Commonwealth Conference of Youth Ministers in January this year: '' I would urge that we should be cautious in accepting the view that the employment problem in developing countries can be solved only if they go in for labour-intensive rather than capital-intensive projects. There can be no absolute dichotomy between the two concepts. Without a balancing of

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truly dramatic. Even without such effort, where transplanted technologies have been responsive to local agronomic and climatic conditions, adoption of innovations has been rapid and has often surpassed projections, as in WADU, Ethiopia's Wolamo Agricultural Development Unit. However, in many other programmes, such as the Ujamaa villages in Tanzania, ZAPI and the Société pour le Développement du Nkam (SODENKAM) in Cameroon, the Special Rural Development Programme (S.R.D.P.) and the small farmer credit programmes in Kenya, and to some extent the Lilongwe Land Development Programme (L.L.D.P.) in Malawi, inadequate adaptive research appears to have been a major constraint on increasing productivity and incomes of low income farmers.', and he ascribes the lack of success in Tanzania to 'haphazard policies of collectivization and by the neglect of critical organizational questions.'

260. For example 'The most economical production of many products will necessitate varying levels of technology for each process, as in the manufacture of textiles, or for each component, as in the manufacture of most agricultural equipment. Thus it is possible and desirable to "mix" many technologies and forms of organization for a single product-large-scale, small-scale and even handicrafts for certain operations.' (Stepanek, 1964.) Many statements of a similar nature were made in other contributions to the "Appropriate Technology" conference in Hyderabad (SIET, 1964).

labour-intensive and capital-intensive projects, development is not possible ... I hope that universities and research institutions in developing countries will not confine their attention solely to the development of intermediate technology." '[261]

3.3 The appropriate transfer and adaptation[262]

In this section I restrict the discussion to chemical production systems, and it is therefore the complement of section 2.4. However, most of the points will have general application.[263] Not very much original is contained in this section, because what is appropriate adaptation seems a rather straightforward technical problem, once the decision to transfer a (reasonably) advanced production system has been made.[264] Further, as far as there exists literature on the present

261. Spensley (1974). 'The fact is that all the time while research institutes working on appropriate technologies are generating one or two ideas, far more resources are being put into research in inappropriate technologies in the developed countries. The producers of machinery in the developed countries persistently continue to expand production of increasingly inappropriate technology for LDCs. We do not live in a static world; each year technology becomes more capital intensive and more sophisticated and the gap gets wider between the needs of the developing countries and what is being provided by the developed countries. It is against this sort of widening gap approach that one has to assess current efforts.' (Stewart, 1972b.)
262. Giral (1972a, 1972b, 1974, 1975), Aráoz (1962), Brauer (1970), Havemann (1973), Jones (1975).
263. In note 168 it has been pointed out that the costs of appropriate adaptation are very small as compared to total project costs and losses due to inappropriate choice. In practice adaptation costs will be seen as part of the transfer costs, and then may be quite significant, in particular for chemical production systems. Teece (1974), who analyzed only 17 international projects, found that: 'technology transfer in chemicals and petroleum refining displayed relatively low transfer costs (as compared with machinery), presumably because it is possible to embody sophisticated process technology in capital equipment, which in turn facilitates the transfer process... In chemicals and petroleum, the results indicate that transfers to government enterprises, and transfers before first commercialization, involve substantial extra costs.'
264. It may be noted that "adaptation" can also be used to adapt the choice of chemical industries to the world market and one's own capabilities. For example, LDCs would then be expected to concentrate on those chemical production systems that require relatively little know-how. Whereas industrialized countries should adapt their chemical units in the direction of higher complexity, other raw materials, and more closed circuits. (Westerterp, 1977.)

subject I have the impression that since, about 1960, not much progress has been made in learning from experience.[265] In reading the following rather simple specifications of how the going about procedures is in appropriate transfer and adaptation, it should be born in mind that the problem areas are the factors impeding an appropriate choice (see section 1.6 and 2.4), not the inherent technical difficulty of appropriate adaptation.

In the choice and implementation of chemical production systems for developing economies, we may distinguish the following stages:

(a) selection of plausible[266] product or products;

(b) select adequate processes from the alternatives available (including obsolete techniques and ideas aborted at the R & D stage of a process);

(c) define clearly the basic differences between the environments for which the process was developed and the given environment;

(d) evaluate the adaptive potential of (b) given (c) and make a provisional choice of process and basic techniques[267] to be used;

(e) negotiate and transfer the base technology (if necessary, include adaptation proposal);

(f) adapt and fill in base design[268] (only at this stage the unit operations are specified);

(g) negotiate and transfer apparatuses or specify task of contractor;

(h) construction.

By far the major factor that disturbs going through these stages appro-

265. This is on the basis of the points made by Aráoz (1962), Brauer (1970) and Jones (1975).

266. "plausible" means that it is on socio-political grounds considered desirable to manufacture these products (locally) *and* that there exist production systems to do that in an economically feasable way (cf. section 1.3.3).

267. Basic technique means e.g. liquid-solid separation, not filtration or drying. See on basic techniques or basic modules as distinct from unit operations and processes chapter 6.

268. The question of control should be balanced carefully. On the one hand automatic control is more capital-intensive, and has no educational value, while proper maintenance and repair give considerable problems. On the other hand, it may prevent breakdown due to carelesness or inexperience of local staff. A slightly different aspect is that restricting the amount of instruments, increases the demand on the process operator. 'The fallacy of economy of scale, which has frequently

priately is, superficially, the dependence of the buyer on the sellers of technology; and basicly, lack of technical sophistication and expertise on the receiving end.

Phase (d) is the critical one. If one is able to make a good choice then the next phases and the details of the adaptation are just a matter of hard work (and insistence in bargaining).[269] In analysing the various possible adaptations of a chemical process, it is useful to distinguish the following aspects.[270]

(i) availability of different processes or parts of them, in terms of patent rights, licenses, pirating possibilities;[271]

hoodwinked technical management in advanced countries, is even more of a mixed blessing for developing countries. The single stream, large capacity plant may tax the ingenuity and skill of the design team, offer richer and fatter contracts during construction, and hold the promise of ever lower production costs; it offers the reverse coin to the operator in a developing country. Under adverse, hostile conditions its lack of flexibility and the loss of production due to even minor hitches causing total shutdown quickly cause unit production costs to rise very rapidly. Thus, at the outset of the project, the criteria for selection of production capacity should not be the minimisation of operating costs, but the maximisation of operational flexibility.' (Jones, 1975.)

269. Of course, again and again suggestions have been made either to set up engineering firms in the industrializing countries as specialized agents for LDCs (Perrin, 1972), or 'To break this dependency, LDCs must endeavour to develop their own engineering capabilities.' Until now only India and Brazil have made significant attempts to establish "bargaining units" of the appropriate level.

270. Elaborating on an idea of Giral (1974, p. 44): 'Criterios para adaptación: 1. Disponibilidad de la tecnologia (costo y etapa de desarrollo) 2. Sensibilidad a la escala 3. Posibilidad de operaciones intermitentes y semicontinuas 4. Posibilidad de operación multiproducto 5. Sensibilidad a la alimentación 6. Flexibilidad de productos y subproductos 7. Severidad de las condiciones del proceso 8. Consideraciones ecológicas 9. Integración con plantas existentes.'

271. 'Technical knowledge can in principle easily be pirated if the selling price is set too high, and penalties against pirating are very difficult to enforce... The would-be pirate must be an expert in the goods if he is not to make a fool of himself. The would-be purchaser (or pirate) must have a technical sophistication and expertise at least as great as that of the seller if the transfer is to be followed by success. The deliberate selling or offering of inadequate or fraudulent knowledge or know-how is very easy and common, buyer beware.... First-rate equipment and materials cannot always be bought, are rarely cheap, and in general are priced at what the international market will bear... Trying to dodge the world market is very likely to lead to faulty material or equipment and eventually to inordinate loss and expense.' (Cook, 1974.)

(ii) sensitivity to scale (this will be discussed more fully in chapter 5);

(iii) possibility of batch or semi-continuous operations, i e basicly simplifying and desintegrating the process;[272]

(iv) sensitivity to raw materials (of apparatus needed as well as product quality);

(v) flexibility with respect to product specifications in view of market to be catered for;

(vi) ecological variables, including the adjustment of the production system to climatic conditions;

(vii) integration with other plants and analysis of alternative multiproduct packages;

(viii) adaptations following from the given infrastructural environment, including the local availability of materials and services;[273]

(ix) adaptation to the different characteristics of the factor labour.[274,275]

272. 'Since in many cases the overseas plants have to be much smaller than the home plants, because of the smaller size of the markets, there are design questions arising from the need to scale down the processes employed; and sometimes it may be more economical to install a batch type process rather than a very reduced version of the continuous process used at home. The majority of the firms had installed scaled-down versions of their more advanced home plants, even though this imposed minimum limits to size so that in some instances it meant that they would be running well below capacity for a few years. These firms felt that they would have better utilization of materials and utilities, better quality of their products, and more ease in their future expansion than if they had installed batch processes... However, if the plant is to be locally owned (by a private firm or by the Government) there is a case for considering simpler or batch-type processes, even for a large plant, if the particular technology allows it, for several reasons: (a) because the investment required will be smaller; (b) because the foreign exchange needed may be smaller, since it may be possible to manufacture locally a larger part of the equipment on account of its greater simplicity; (c) because the cost of labour will probably be lower than for a foreign manufacturing subsidiary (which would often be obliged to provide more elaborate welfare facilities and perhaps pay larger wages than a "local" firm will have to do); (d) because the advanced process requires more care in operation and higher technical skills in maintenance, so that investment may be squandered through inefficient running of a plant using such a process; (e) because the simpler processes have more educational value. In the case of locally-owned plants, therefore, the prevalent policy of wholesale adoption of the most up-to-date techniques and equipment in many cases may be inadvisable.' (Aráoz, 1962.)

As the UNIDO (1977c) keenly remarks 'experience in selection of technology has shown that wrong choices are possible'.[276] Nowadays really everybody agrees that,at least,'The appropriate choice of technology ... is therefore likely to become more formidable and challenging in the years to come'. But this misses the point: To make an appropriate choice in the sense of going through phases (a) - (h) and checklist (i) - (ix) appropriately, just requires the will to do so and a lot of money. The UNIDO or the "State Office for Appropriate Adaptation" is not capable of judging the appropriateness in a techni-

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273. In section 2.4.2 a number of typical design errors have been listed. It is not difficult to make checklists for a number of parameters. See e.g. Havemann (1973). In compressed form such lists run as follows. Temperature: air- and watercooling, high radiation (direct: plastic construction materials, indirect), temperature fluctuations (expansion, condensation), effects at higher altitudes; moisture: storage and packaging, dryers, corrosion, microbial growth; wind: sand and dust, orcanes /typhoons, corrosion (salt); water: no cooling water, heavy rain (buildings and lay out, transport); ecology: insects, microbes; communications: road condition, maximum size or weight, time lag, telephone unreliable; isolation: long periods during which goods are in transit, standby equipment, spare parts; power. The relative isolation affects a number of wider issues. For example, the following recommendations have been made: use of "good enough" items available locally instead of asking for "the best" which will have to be imported; facilities for maintenance and repair set up parallel to the production unit (including training); key off-site units for power, process water and steam. Although there are "good" effects, the overall effect of the isolation tends to imply a strong isolation from the economy and the social system of which the production unit should be a part.
274. Apart from direct production factors such as "skills", this may include such various secondary problems as: language problems; low level of health (many illnesses, standby for important functions); sensitivity to working in closed areas and air conditioning; animosity between different groups; religious values (holidays, food, leather). It is clear from this list that the environment is not very suited for an efficient production system.
275. Giral (1975) describes a number of successful adaptations. The following two illustrate adaptation of type (c) and (e): (c) The expansion of a given unit would involve, because of the economies of scale the use of a continuous filter and a spray dryer. By adapting the reaction conditions it was possible to change the particle size of the precipitate and hence filtering and drying times in a filter press + tray dryer could be halved. (e) Often products are made of which the quality is too good. For example when no automatic cutting systems are used by the end users of plastic films the dimensional stability required from the films does not have to be that strict, e.g. a stretcher-relaxer in a controlled atmosphere can be replaced by an elementary 3 roll, wind-up tension control mechanism.

cal sense. But, if there is a market for engineering firms specializing in adopting and procuring certain types of production systems that have to meet "odd" specifications, then they will emerge - provided one is prepared to pay.[277]

3.4 The case for indigenous technology[278]

3.4.1 Processes of change. In connection with production systems, two major processes of change should be considered. Firstly, the development (in time) of a production system, in particular the stages before the mature production system is producing within its environment. Secondly, the fact that the introduction or adaption of a (new) production system involves a process of change in that particular environment. Ideally these two processes should be integrated, such that the environment (in which the production system eventually will take part) induces the development or the transfer and adaption of the production system. In other words: the environment influences the choice and/or

276. Although, in a UNIDO publication of 1963 we find already: 'The adaptation of processes, equipment and products to local conditions is constantly under review by industrial engineers and managers in every country. It is well known that technological change and innovation have primarily taken place under the stimulus of conditions obtaining in the developed countries where the main body of technological knowledge, skilled manpower and advanced equipment exists. The under-developed countries present, in most cases, a different environment with respect to factors of production, availability of managerial and supervisory skills, nature of raw materials, fuel and power supplies and repair and maintenance facilities, climatic conditions, general economic organization, and domestic and foreign marketing opportunities.' It is possible therefore to express some doubts when it is stated that 'Summarizing UNIDO programmes in transfer of technology, they may be characterized as an integrated and complex activity covering not only the various possible stages of the process but also the broadest possible area and potential as well as the existing implications and impact on national economy. Because of the horizontal dimensions of technology transfer and its special key-role in the industrialization process, UNIDO is viewed as a unique organization within the UN systems offering complex, integrated and indepth solutions backed primarily by its internal in-house human resources and expertise.' (UNIDO, 1977c.)
277. This conclusion is not a plead for capitalism. The way of phrasing only implies that I am -in the given mondial context- rather sceptical with respect to the possibility of getting the right people to work for socialist salaries in democratic organizations. (Just think of what UN-organizations pay, and what, on average, they get for their money.)

development of the production system "as much" as the production system will influence the environment when it is in operation. Of course the foregoing is, firstly, rather vague (in particular as regards which people to include in the environments;) secondly it blurs the fact that the social part of the environment is not homogenous (different groups have different interests); thirdly, external intervention is very often both impossible to prevent and seems appropriate; and finally, succes is under no circumstances guaranteed (because not all consequences of actions chosen are foreseeable). Nevertheless, I think the concept of integrating the two processes of change is useful, because the further away one is from the ideal, the more complicated the process of change in the environment will be; and the more difficult it becomes to judge what would seem to be appropriate.

The following list of stages in de development of a production system might have been introduced in section 1.1 (or 1.6, or 2.2), but I think the implications of the list (or any similar one) can be better appreciated in the light of the contents of the previous chapter. The list then is as follows:[279]

(a) a need of (a part of) a society is identified;

(b) goals and differences between the goals of different groups are identified;[280]

(c) relevant areas of technology and available hardware are identified;

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278. The most elaborate exposition of the case for indigenous technology I know of is by Onyemelukwe (1974), (who is mainly interested in medium scale rather sophisticated production systems). For rural development "indigenous" is part of "appropriate" as commonly understood. 'In deriving the appropriate technology, one should start with a study of the actual production operation and circumstances in the rural areas concerned. As much as possible, research for appropriate technology should start with a close examination of existing indigenous technology in the subject concerned to see whether this may not in fact be most appropriate; when it is clear that the existing indigenous technology is inadequate, a first approach to deriving an appropriate technology should be sought in the modification and reinforcement of existing indigenous technology.' (DSE, 1972.)

279. In constructing this list I benefited from Stewart (1972), Collombon (1975), and Bell (personal communication).

(d) alternative ideas for products (methods, goods or services) to fulfil needs/goals are developed;

(e) specifications of alternative production systems are developed, including their technical characteristics, economic feasibilities, institutional requirements, and socio-cultural implications;

(f) alternatives (e) are evaluated in terms of (b) and a choice is made;

(g) a prototype or raw material is developed or acquired and tested in the field;

(h) the prototype or raw material is tested in a real socio-economic setting and again evaluated in terms of (b);

(k) inputs of the production system become available on a commercial scale and the production system is adopted throughout society wherever appropriate.

These kinds of checklists are usually formulated in a language that already implies that some external agent of change is steering or at least guiding the process of change. The case for indigenous technology may be nummarized as stipulating that the people involved in stages (a) - (k) are indigenous, in particular those who choose, those who guide, those who finance, and those who actually do the work (of developing and operating the production system). The case for indigenous technology does not imply that (i) communities of every size should be self-sufficient in every respect and (ii) it is forbidden to consult a foreign book or buy phosphoric acid abroad - but it does imply that at all levels new ideas should be tried out and one should not run away from problems to concentrate on spectacular aid projects.

3.4.2 Why indigenous technology ? The case for indigenous technolo-

280. 'It is not agreed among those who work in this field: (a) whether the "goals" which an IPS is designed to further should be externally selected, or formulated within a society or community (a village, for example), (b) whether goals can be formulated, in a way that could yield a technical specification for an IPS, within a society that may be unaccustomed to explicit formulations and will most certainly be devided into different social classes who may, before or after discussions, have different perceived interests, (c) whether or not the installation of an IPS will bias the subsequent development of goals, i.e. whether production systems do or do not have effect on the development of goals by affecting social values.' (Keddie and Cleghorn, personal communication.)

gy can be interpreted as the consequence of acknowledging the analysis of the "dependence" theory (see section 2.1), combined with the realistic attitude that just making the political structure right is not a sufficient condition for appropriate development. Positive reasons for indigenous technology are rather vague, the major one being that, in order not to disrupt a socio-cultural system, the process of technical change should be an "organic" or "logical" sequel on the present situation. Technology and culture need to change simultaneously. Nobody says that is easy. Some say that it has not been very succesful in the industrialized countries, hence the more reason to be thoughtful. Others say local elites are worse than external ones. That may be the case (and *is* a problem then), but that does not affect the following reasons supporting the case for indigenous technology:[281]

(a) It is not possible to jump over the technology gap. By apparently doing so one only creates enclaves in a society, which is itself further alienated both from its own and foreign technology. 'There may be many shortcuts here and there, but in the end one has to tread warily and patiently through the entire tortuous path to accumulate the knowledge of what is best suited to one's needs.'

(b) Almost all aid is bound in some way or other. This leads to the kind of problems enumerated in chapter 2. Because of the aid, and more so because of inappropriate aid, political relations between donor and

281. 'Development cannot gather momentum in any underdeveloped area unless there is an indigenous technology. An indigenous technology means a technology that really takes root and once rooted begins to grow its own branches, gathering nutrition from the fertility of the soil in which it grows. In short, we are looking for that kind of influence which generates confidence and spontaneity in a people's own ability to succeed. We are looking for know-how shared by the largest number of people in the community. The confidence and spontaneity must be shared by a large percentage of the ordinary people and not by an elite only. Elite expertise cannot support the enormous momentum required to achieve take-of....The idea of an indigenous technology has of course vast social, political and cultural implications. It is an expression of confidence in the belief that no people whatever their culture are incapable of initiating and carrying on a development effort. It means that instead of the present attempt to manipulate and change the socio-cultural characteristics of a people to fit the claimed norms of Western industrial societies, the people themselves now sow the seeds of industrialisation in their community with their own hands. (Onyemelukwe, 1974, pp.28-29.)

recipient are fragile and degenerating. More generally this leads to

(c) the effects due to the dominance of the Western culture in the dependence relation. In aid projects LDCs are automatically forced to be on the receiving end. Most of the time they are flooded by expert economists who, on arrival, start to make a national plan for the first time in their life, trying to live up to the expectations of being a thunderbird; and volonteers who stay for three months, or perhaps two years,to upgrade a village with the help of their "Appropriate Technology Handbook", and perhaps some common sense. It is rather irrelevant how inappropriate the results of the external adviser are. It leads to a passive state and the impossibility of ever contributing anything significant.

3.4.3 Levels of indigenous technology. It may be good to repeat that indigenous technology does not imply either complete isolation, or small-scale for all production systems. We may distinguish the following levels:

(a) Improve traditional production systems. This is a highly neglected area. Due to the competition of "modern" products that substitute the tradidional ones,family and small-scale traditional production systems are declining everywhere. Almost everywhere the knowledge about traditional production systems of people involved in development projects as well as indigenous scientists and technologists, is negligible. Even when some cottage industries are politically supported (as e g in India), only protective measures are taken but no serious attempt is made to improve, upgrade, and diversify these traditional production systems.

Just saying that cottage industries are good and taking some general measures to show one's concern, is no good. A detailed analysis has to be made of all existing productive activities, and then slow processes of change should be started. Many of the existing activities are marginal in the extreme; that is to say: Attempts to improve traditional production systems usually have the effect of proposing a more efficient production system by which a better (healthier) product is made in a safer way - which system, when introduced, completely disturbs the local economy because the price of the product is slightly higher and the original producers loose (part of) their job.

Hence, the type of actions taken may be very different, but are always affecting large changes in the long run. In a particular environment actions taken could include: Protect the market of locally produced soap and dyes and investigate whether product improvements are possible without increase in cost; do not protect textile production by hand loom (because there is no future for this production method); retrain potters to make drainage pipes; introduce new skills in metal working; investigate whether the "lost-wax" process,[282] traditionally used to make objects of art, can be used to make metal parts for no-precision machinery and so on.

(b) Transfer of production systems which have proven their mettle in an environment similar to the environment considered. This type will normally not be a transfer from overdeveloped countries to LDCs, but inter- or intra- LDC-transfer. (On a global scale this may of course induce the emergence of a new class of dependence relations.)Transfer of this kind has been increasing over the past ten years, but communication channels are still of very low quality.

(c) Adaption of medium scale production systems "from the shelf" to local circumstances. The most common adaptations will be to local raw materials, by using more labour-intensive techniques, by using machinery that can be produced locally, and by adaptation of the product. Probably the most important group of production systems here for indigenous development is in the mechanical sector: agricultural tools and apparatuses and low-cost utility products, such as sewing machines and bicycles.

(d) Pirating or buying of advanced technology.[283] However, to fulfil the criteria of idigenous technology the minimum requirement should be that one can operate and maintain the system oneself. This

282. See on the "lost-wax" technique for example SAED (1976). Attempts to use this technique for making machine parts have been made at TCC-Kumasi (see section 4.3.2).

283. See Onyemelukwe (1974, pp 92-93) on the disadvantages of a common market to take advantage of the economies of scale. The larger scale implies higher sophistication and hence more dependence.

implies that usually such transfers are preceeded by periods of training.

(e) Generation of "new" technology. This will often involve developing production systems based on particular raw materials e g the possible use of hardwood to make machine parts or the use of particular clays to make non-traditional building materials.

In those cases where natural resources can only be exploited and sold on the world market by using very sophisticated capital-intensive production systems, I think it is consistent with the "indigenous"-philosophy that such a case is considered to provide a possibility of earning money and not a possibility to further industrialisation. When established , these production systems may deliberately be treated as an enclave and no time or money need be spent to try to integrate it with the surrounding economy or culture.

3.4.4 The possibility of indigenous technology. During the civil war in Nigeria: 'Cut off from the outside world because of the Federal government's blockade, engineers and technologists there had to go to work. What resulted was a wide range of consumer and non-consumer goods, e.g. petrol and diesel, toilet and washing soap, face-cream, vaseline, biscuits, liquors, dyes, chalks, engine oil, protein extracts and salt, all produced in small-scale units at a fraction of the capital/output of equivalent installations in Europe or in the rest of Nigeria at the time.'[284]

So called "specialists" are usually of the opinion that the ideas expressed in this section are just an idealistic hotch-potch: only good American engineers can do good work. I think that all empirical evidence supports that if need be *and* the political context provides

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284. Onyemelukwe (1974). Cf section 2.4.3.
285. See Jéquier (1975).
286. In the next two chapters more specific examples are given. For example processes or machinery developed indigenously, but not applied (see NRDC-India, section 4.5.1); processes or machinery commercially produced by foreign firms (gari processing in Nigeria, see section 5.2.4 and coffee-bean-sorting machine by EAIRO, see section 4.3.1); sophisticated plants owned operated and maintained indigenously, but in a difficult economic position due to unreasonable high taxes and low prices (cement factory in Indonesia, see note 484).

enough incentives most of the impossible is possible. The example in the previous paragraph illustrates that most commonly the impossible is achieved in war (-like) situations. Examples from other cultures and times include[285] the USA during the War of Independence; Sweden and Germany during the second World War, and Japan and China during periods of extreme isolation.

However, on a smaller scale, deliberate measures of indigenesation are often unexpectedly succesfull. For example, since 1965 various African states set restrictions on activities of foreigners in retail and whole-sale and in many cases it appears that the vacuum is filled quite easily. Of course, due to such factors as irritation and pride, positive anecdotal evidence of nationalisation (or indigenesation) is seldom heard of, whereas, as far as chemical production systems are concerned, I know of not one detailed microevaluation.

This is not to say that there are not many disasters, following from such policies. Although this may seem an ad hoc argument, I think that these disasters have to do with the necessary condition of a favourable political context, and not so much with the technical incapability. In the previous chapters enough has been said on the factors impeding the appropriate choice, implementation, and operation of production systems.[286] I shall not pursue this matter here any further.

4. APPROPRIATE INSTITUTES ?

4.1 Types of organisations

In this chapter a survey is given of institutions promoting, developing, servicing, ... appropriate production systems.[291] A number of more established institutes is included to provide some perspective. The sample is biased in two respects: Firstly, this report is on chemical production systems; therefore organisations solely interested in agricultural or health aspects are underrepresented. Secondly, only organisations are described which I was able to visit[292] or about which I could otherwise obtain a significant amount of information. Geographically speaking Latin America is hardly represented. I think, however, that the survey is broad enough to give an indication of what is going on.

In table 6 most of the institutes mentioned in this chapter are enumerated. Some of them will be described in detail; others only briefly mentioned in notes. Classification, as usual, is difficult. I have distinguished four main headings:[293]

291. The number of organisations (said to be) involved in appropriate production systems is already astronomous. In a survey carried out by US-AID (1976) 'more than a hundred organizations involved in appropriate technology in 32 African countries' were identified. See for announcements of new looks inter alia the VITA- and TRANET Newsletter.

292. Of the institutions mentioned in table 6 the following were visited: DLI, ECA, ESTC, EAIRO, FAO-Rome, GhRRM, IDS-Sussex, IDS-Nairobi, IFO, ILO-Geneve, INADES, IRC, ITDG, ITIPAT, KIEL, OPEI, OECD, SIDO, SPRU, TCC, TOOL, UNDP (Ouagadougou, Accra), UNEP -Nairobi, UNIDO-Vienna. In the course of this project also visits were made to the universities at Lagos, Ife, Zaria, Legon, Kumasi, Dar-es-Salaam, Nairobi and Addis Ababa.

293. Koppel and Hansen (1976) distinguish: universities, research institutes, extension agencies, management institutes, and private industry, and list their 'assets and liabilities' as well as what is 'needed to become an appropriate institution for appropriate technology'. Their approach is rather static, only stating what should be, without analyzing processes of change involved and *how* to induce these.

(a) S & T policy units. Formal institutions of this type usually operate at the government level. But there are, of course, many organisations whose main task is something different which nevertheless have a big influence on opinions in S & T policy. Organisations involved in aid-projects have been described in section 3.1. In LDCs-government-institutions often policy-, research- and executive tasks are combined; classification may therefore be somewhat arbitrary.

(b) R & D institutions. This is a rather clear category, mainly consisting of universities[294] and government research institutes.

(c) Agents of change. Under this category come organisations who interact directly and on their own initiative with production systems (i e with the people operating those systems).

(d) Linkage area. This comprises the organisations that provide services to production systems on the request of the latter. Of course the border line between (c) and (d) is fluid.

4.2 S & T policy bodies

4.2.1 Government organisations. The structure of science and technology in LDCs usually resembles that of the USSR: all research institutes come under some national council;[295] there are special councils for important branches of economic activities such as agriculture; ministries have offices or advisory boards that partly duplicate the councils; and institutes of higher education are part of again another structure. There are very few countries that have adopted a kind of "appropriate technology" philosophy in the highest S & T policy bodies. The only possible examples I know of are in Ethiopia (see below) and

294. The term "university" is meant to denote also higher institutes of technology.

295. For example in India, there is the Council of Scientific and Industrial Research, officially coordinating about 35 national and regional research laboratories, employing about 14,000 scientists. (Some government departments have specialized laboratories that are not part of this structure.)

296. Such offices are more recently also formed in industrialized countries, one of the first being a Centre in the Governor's Office of California (USA). These developments are related to the 'science for people' movement in overdeveloped countries.

TABLE 6 Institutions involved in appropriate production systems

abbreviation	name	section
ACAST	Avisory Committee on the Application of Science and Technology for Development (UNO)	3.1.1
AIT	Asian Institute of Technology (Bangkok)	ch. 6
ASTRA	ASTRA-Cell, Indian Institute of Science (Bangalore)	321
ATC-Del	Appropriate Technology Cell, Indian Ministery of Industrial Development (Delhi)	4.2.1
ATDA	Appropriate Technology Development Association (Lucknow, India)	4.2.3
ATDO	Appropriate Technology Development Organisation, Pakistan Ministry of ..., Planning, ...	4.2.1
ATIN	Appropriate Technology Information Network (Brace, GRET, ITDG, TOOL, VITA)	4.5.4
Brace	Brace Research Institute (Quebec)	4.3.3
CCPD	Commission on the Churches' Participation in Development, World Council of Churches	366
Cecoco	Cecoco Agricultural and Small Industrial Centre (Japan)	4.5.1
DLI	David Livingstone Institute for Development Studies, University of Strathclyde (Glasgow)	4.3.4
DSE	Deutsche Stiftung für Internationale Entwicklung (Berlin)	
EAIRO	East African Industrial Research Organisation (Nairobi)	4.3.1
ECA	UN Economic Commission for Africa (Addis Ababa)	
ESTC	Ethiopian Science and Techn. Commission	4.2.1
FAO	Food and Agricultural Organisation of the United Nations	
FIIR	Federal Institute of Industrial Research (Oshodi, Nigeria)	4.3.1
GhRRM	Ghana Rural Reconstruction Movement (Accra)	4.4.1
GIDS	Ghandhian Institute of Development Studies (India)	304
GRET	Groupe de Recherche sur les Techniques Rurales (Paris)	4.5.3
IDS-Nai	Institute of Development Studies, University of Nairobi	4.3.4
IDS-Sus	Institute of Development Studies, University of Susses	4.3.4
IFO	IFO-Institut für Wirtschaftsforschung (München)	336
ILO	International Labour Organisation (UNO)	3.1.4
INADES	Institut Africain pour le Développement Economique et Social	351
IRC-WHO	International Reference Centre (World Health Organisation)	363
IRRI	International Rice Research Institute (Manilla)	4.3.3
ITDG	Intermediate Technology Development Group Ltd. (London)	4.5.3
ITIPAT	Institut pour la Technologie et l'Industrie des Produits Agricoles Tropicaux (Abidjan)	309
JCI	Japan Consulting Institute	4.5.1
KIEL	Kenya Industrial Estates Ltd. (Nairobi)	4.4.3
KVIC	Khadi and Village Industries Commission (Bombay)	4.4.2
NRDC	National Research Development Corporation of India	4.5.1
OECD	Organisation for Economic Co-operation and Development	3.1.5
OLC	Overseas Liaison Committee of the American Council on Education	380
OPEI	Office pour la Promotion de la petite et moyenne Entreprise Ivoirienne (Abidjan)	4.4.3
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer (France)	310
PRAD	Planning Research and Action Division, Uttar Pradesh State Planning Institute (India)	4.3.3
RATC	Regional Adaptive Technology Centres (South East Asia)	4.3.2
Sarvod	Sri Lanka Jatika Sarvodaya Movement (Colombo)	4.4.1
SATA	Swiss Association for Technical Assistance	384
SENDOC	Small Enterprises National Documentation Centre (SIET, India)	377
SID	Society for International Development (Paris)	4.5.2
SIDN	Small Industry Development Network, Georgia Institute of Technology (USA)	380
SIDO	Small Industries Development Organization (Dar-es-Salaam)	4.4.2
SIET	Small Industry Extension Training Institute (Hyderabat, India)	4.4.3
SPRU	Science Policy Research Unit, University of Sussex	4.3.4
SSIDO	Small Scale Industries Development Organization (India)	354
TAICH	Technical Assistance Information Clearing House, Am.Council of Volunt.Ag.for Foreign Service	380
TAMTU	Tanzanian Agricultural Machinery Testing Unit	348
TDAU	Technology Development and Advisory Unit, University of Zambia	321
TCC-Kum	Technology Consultancy Centre, Kumasi University of Science and Technology (Ghana)	4.3.2
TOOL	Stichting Technische Ontwikkeling Ontwikkelingslanden (Amsterdam)	366
TPI	Tropical Products Institute (Great Britain)	4.3.1
TRANET	Transnational Network for Appropriate/Alternative Technologies	380
UBARI	Union of Burma Applied Research Institute	4.6
UNDP	United Nations Development Programme	200
UNEP	United Nations Environmental Programme	3.1.3/4.5.2
UNIDO	United Nations Industrial Development Organisation	3.1.6
US-AID	Agency of International Development of the US-government	4.5.3
VITA	Volunteers In Technical Assistance (USA)	

Tanzania. More common is, that somewhere within the government an "office for appropriate technology" has been set up.[296] Examples from India and Pakistan are given below. Of course, in such a construction these offices have to compete with the vested interests of other offices and councils.

The *Ethiopian Science and Technology Commission* (ESTC), established in December 1975, has as its principal purposes:

'(1) to encourage, strengthen and guide the search for scientific knowledge and the pursuit of technological developments emanating therefrom applicable to the alleviation and surmounting of hardship in the life of the broad mass of Ethiopians as well as to raising their productivity, and

(2) to encourage, strengthen and guide the search for Ethiopia's natural resources and the development of those technologies which applied thereto serve to win optimum yields in all sectors.'[297]

The Commission seems to be endowed, both formally and practically, with enough power to affect these purposes. For a country such as Ethiopia, which is among the poorest LDCs, with few but nevertheless a significant number of indigenous scientists and technologists, this seems to be the best structure. My impression is that most R & D activities in Ethiopia are now concerned with "appropriate" or "intermediate" production systems, although these adjectives are rarely heard.[298]

The *Appropriate Technology Development Organisation* (ATDO), within the Pakistan Ministry of Finance, Planning and Economic Affairs, was established in 1974 following a visit by an ITDG-team. Its task is 'To simplify the technology to the level that it can be understood and practised by people without resorting to costly and time consuming elaborate training... To link up production with employment ... To ensure employment work place at lower capital cost ... To mobilise people to undertake planning and execution for themselves. To create a highly motivated technical cadre with correct social and political attitudes who can provide leadership, and also fill-up managerial gap at village level, ... To help people, set up village workshops for fabrication of agri-

297. See Proclamation No.62 in the Negarit Gazeta of Dec.5, 1975. Quotations given are taken from the proclamation. For example: 'to propose re-organization, abolition or transfer to the Commission , of any Government institution or part thereof engaged in scientific and technological research and development; to require any person or institution undertaking scientific of technological research and development to surrender to it one certified copy of all documents;
298. This conclusion is based on impressions gathered during a visit to Ethiopia in August 1976. Also at the University of Addis Ababa, mainly staffed with young Ethiopians, all research projects have to clearly contribute to one of the two principal purposes. It may be interesting to note that the UNIDO mission attached to the ECA headquarters in Addis Ababa was, at that time completely aware of what is happening in Ethiopia.

cultural implements, carry out repairs and manufacture small industrial plants.'

It is to carry out this programme with the help of research institutes and industries. In 1976 quite a large budget became available and now about 20 projects are under way,[299] whereas lower governments have commissioned the technical supervision of development projects under their jurisdiction to the ATDO. At face value the activities of ATDO look promising, although it is not very clear how exactly they intend to implement the latter three of the above tasks.[300]

The *Appropriate Technology Cell* (ATC-Delhi) was created in 1971 in the Indian Ministry of Industrial Development. Together with its inception the first national conference on appropriate technology was held and a number of working groups were established. Four of these (road construction, building construction, scaling down of cement plants and cow-dung gas plants) reported[301] at the second national meeting in 1974. Its task is said to be 'to make suitable technology available to artisans in rural areas and small-scale industrial units so that they can earn more and also produce more.' It is also stated that it should 'establish a bridge between the research installations and the needs of the community'. It is not exactly clear what the specific linkage function of the AT-cell would be as distinct from the tasks of the many other organisations that already exist.[302] To me it seems that there is room for an AT-cell in the government which tries to influence what other institutions do. If there is a wide gap between laboratory results and field operations then the existing research institutes should be stimulated or forced to engage in field operations.

4.2.2 International organisations. The activities of the members of the UN-family, in particular UNIDO, ILO, UNESCO, UNCTAD, and FAO, influence (or are the outcome of) S & T policies through the decisions that are made on major conferences and the research programmes they initiate (but which are usually paid for by particular industrialised

299. Including the following chemical processes and physical operations: fertiliser and methane from cow dung, insecticide from tobacco waste, paper pulp from bagasse and banana tree waste, small-scale oil expellers and paddy driers.

300. An Appropriate Agricultural Technology Cell with similar goals (but restricted to agriculture) was set up in Bangladesh in 1975.

countries). The activities relevant to this report have been discussed in section 3.1.

4.2.3 Private organisations. Indirectly S & T policy is influenced by (i) a number of "promoting" organisations in the linkage area (see section 4.5), and (ii) S & T policy and economic research carried out at research institutes such as SPRU and IDS of the University of Sussex (see section 4.3.4), as well as (iii) the organisations that finance such research, such as the *International Development Research Centre* (IDRC). (IDRC was established in 1970 by act of the Canadian Parliament: 'a public corporation supporting research designed to adapt science and technology to the specific needs of developing countries')[303]. About all private organisations involved in promoting "the new look", are also engaged in some practical activities, and a number of them will be discussed under subsequent headings. Here only one typical example follows:

The *Appropriate Technology Development Association*[304] at Lucknow,

301. See Behari (1975). Other working groups include: agricultural implements and tools, leatherprocessing, small-scale dairy plants, ceramics, food processing and preservation, wood processing (incl. furniture),...

302. Such as NRDC, KVIC, SSIDO, SIET, PRAO, and the various national and regional research institutes of the CSIR (cf following sections and table 6). A number of successful promotions of the AT-cell(including efficient stoves, a dairy, agricultural tools, and methods of road construction) were concerned with methods or machines developed at research organisations and could well have been taken up by the existing extension services. Of course, the AT-cell is forced to promote their successes to prove its existence. (Digression: If, however, there would be a wise minister the, then more secret, cell could give the established organisations (or persons in such organisations) the credit of succes, and that kind of policy might have more succes in changing something, instead of protecting one's institution. Alas, who knows a wise minister, and who will there be tomorrow.)

303. In fact IDRC was established by IDS-Sussex. Important programme include: the development of an international research network for cassave (Nestel and Cork, 1976), a comparitivestudy on science and technology policy implementation in less-developed countries (IDRC, 1976a - see section 2.2.1), and "A Latin-American World Model" (IDRC, 1976b - see section 2.1.4.).

304. The Association was set up in 1972 as a unit of the *Gandhian Institute of Development Studies* (GIDS) and became independent in 1975. The Gandhian Institute has itself been active for a long time in promoting the new-look in India. In 1967 it organized a seminar on 'problems and prospects in intermediate technology' and three similar conferences in later years.

Utter Pradesh, India is an independent non-profit organisation with the objective 'to promote development of appropriate technology, specially for the weaker sections of the communities and for the backward areas; the main thrust being in the direction of building up technically feasible and economically viable models by scaling up the basic village technologies, scaling down large scale technologies, and finding out alternative decentralized energy sources; ...'[305] The ATDA has concentrated on working out 'integrated package plants which can be offered at the same level as that of large-scale plants'. It has published a "Directory of Machines, Tools, ..." relevant to "appropriate technology" and a vieuw technical publications.[306]

4.3 Research and development institutes

4.3.1 National Research Organisations. As has been indicated in section 2.2.2 research institutesin LDCs have not lived up to expectations. Government research institutes have been established everywhere to support industrial development,[307] but it appears that in practice

305. The complete list of objectives includes everything any other organisation mentioned in this chapter might be doing. Hoda (1974abc) and Garg (1974abc, 1975) are attached to the Association (cf section 4.3.3 on the PRAD, also in Lucknow). See on the ATDA in particular Hoda (1974a).
306. For example on "mini-sugar technology", "decentralized pottery technology", "rice milling industry". At present they are particularly engaged in 'a technology of decentralized spinning for handloom weavers'. It is difficult to entangle exactly which activities come under ATDA and which under PRAD.
307. By far the largest effort in this respect has been made in India. As far as chemical production systems are concerned institutes such as the "National Chemical Laboratory", the "Central Electrochemical Research Institute", the "Central Glass and Ceramic Research Institute", and a considerable number of other central and regional institutes (notably those of Jorhat, Jammu, and Hyderabad) are engaged in adapting chemical processes which are not normally used for making a particular product, but which become feasible only because they use as raw materials basic chemicals that are already produced in that country. Typical examples of chemical processes that have been adapted such that only indigenous available materials are used are: barium sulphate (X-ray grade), catechol, many vegetable oils, silicagel, citronellol, lithium salts, membrane filters, monoethylaniline, phenyl acetic acid, active carbon, menthol. See also section 4.5.1 on the NRDC-India.

there is no point of contact between production and research.[308] The interest of these institutes in the traditional and smaller production systems is even less. R & D is concentrated on modern export industries[309] or production systems that are designed for import substitution. Below three representative organisations are discussed, all three of them dating from before the "new look" revolution, but engaged in many subjects that would normally be classified as appropriate.

The *Tropical Products Institute* (TPI) was established in 1894 and became in 1965 a part of the British Ministry of Overseas Development.[310] 'TPI exists to help the developing countries of the world make better use of, and derive greater benefit from, their "renewable natural resources" - that is, mainly, their plant and animal products. It specialises in the post-harvest sector and so is concerned particularly with

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308. 'The major applied scientific research institute in Thailand provided an excellent illustration of the difficulties confronting scientific research in poor countries, and particularly of the problem of "coupling" scientific research with the requirements of local industries. Generally their research found no apllication at all.' (SPRU,1976,p.26) 'The Egyptian National Research Centre nevertheless has not realised the intended goal of establishing the required link with Industry. The main reasons for that are summed up in the following: 1) Poor Contacts with Industry and lack of experience concerning industrial activities among the responsibles in the centre. Contacts being mainly excercised through the Ministry of Industry itself and not the Industrial Units directly. 2) The system of personnel promotion for research workers within the national research centre itself, was closely connected with the aquirement of scientific degrees disregarding the economical return of the research involved. 3) Lack of experienced supervisors in Industrial research within the National Research Centre. 4) Lack of funds dedicated from the Government or from the Industrial enterprises themselves. 5) The Governmental system dominating the National Research Centre as well as the Industry'. (Garrana, 1976, Chairman Misr Chemical Industries, Alexandria.)
309. For example ITIPAT *(Institut pour la Technologie et l'Industrie des Produits Agricoles Tropicaux)* is solely directed to ultramodern processing of products. It is a large institute, equipped with the most recent analytical instruments and good pilot plant facilities. Now, this may all be useful to earn foreign exchange, but it is nevertheless a pity that the Institute is not even aware of the existence (and hence the problems) of traditional production systems for tropical products.
310. In France there is ORSTOM. *(Office de la Recherche Scientifique et Technique Outre-Mer)*, a large organisation with branches in all francophone countriesin Africa. It is mainly concerned with agriculture and geology and very little with production systems. As far as I know the new look has not yet reached ORSTOM.

such matters as: crop handling; drying and other forms of preservation; storage; transport; processing; quality control and safety; standardisation; the development of new products, processes and equipment; national and international markets and marketing; and the problems of existing or new industries based on plant and animal products (particularly rural and agro-industries).' The Institute has a staff of about 380 of which many undertake assignments overseas. It has a very large R & D programme,[311] provides technical training oppertunities for people of LDCs and deals with numerous requests by post for information and advice. Originally TPI was predominantly chemically oriented, over the past 15 years it has become more polydisciplinary.

In 1972 TPI adopted the new look under the name "optimal technology", distinguishing traditional production systems at subsistence level, import substitution, and export industries, each asking for its own technology.[312] TPI has developed a considerable amount of improved or new production systems that have been implemented. However, no systematic evaluations of classes of related projects exist. I have the impression that on average their results are quite good, but at relatively high costs.

The Federal Institute of Industrial Research (FIIR) at Oshodi (Nigeria) was established in 1956. The objectives of FIIR are: (i) to look into the industrial utilization of indigenous raw materials by carrying out pilot-scale trials and assessing the commercial viability of technically feasible processes; (ii) to offer technical assistance. The activities of FIIR are hampered by staffing problems due to rapidly expanding universities and industries, respectively offering better opportunities and higher salaries. Besides that there are the problems

311. Research projects that bear on the chemical production systems discussed in the next chapter include: extracting coconut oil at the same time isolating the protein which is present in the coconut milk, substitution of materials such as cassave or sorghum in bread, design of equipment for the decortication of cashew nuts (now commercially produced), artificial drying of spices and other products, development of a mobile distillery for bay oil (a full-scale distillery is now operated by a cooperative on Dominica) and other studies on essential oils, charcoal production, traditional methods of vinegar manufacture, use of non-conventional energy sources, biologically active agents from wild-plants, and many purely chemical studies related to the preservation of fruits, vegetables and fish.

312. See Spensley (1974) and note 29 and 261.

of transferring the results of research to the industrial sector of the economy.[313]

The development and promotion of the production of gari (a cassave food product), one of the institutes major projects will be discussed in section 5.2.4.[314]

The *East African Industrial Research Organisation* (EAIRO) at Nairobi (Kenya), was set up in 1942 to 'assist with industrial research ... when it became apparent that East Africa would have to manufacture some essential goods to avert the shortages brought about by the difficulty of importing from overseas at that time due to war conditions.' At present it has a staff of about 40 and sections for ceramics, industrial chemistry, fibre technology, coffee processing, cereal processing, and food processing.

As the EAIRO is one of the best research organisations of its kind[315] - given its size and available resources for expensive laboratory equipment even so when compared with many of the government research organisations in Western Europe or the USSR - it provides a good example to illustrate the structural problems involved in establishing appropriate production systems.

In table 7 the research carried out during the war is listed and in table 8 most of the research carried out after the war.[316] Apart from the products and raw materials concerned it is indicated whether (partly) as a result of the EAIRO research the stage of commercial production was reached. The difference between the two periods can be called significant. Of the 15 products that were "commercially" produced during the war only three production systems survived: vegetable oil refining and hardening, pyrethrum extraction, and soap - the latter[317] only with difficulty and continuous support of the EAIRO. The others

313. This point has been stressed by the former director (Akinrele, 1972), who gives as major reasons: (i) industries are foreign based and bound to traditional raw material suppliers overseas; (ii) reluctance of local financial institutions to grant credit to Nigerian entrepreneurs. At present the situation seems to be much better, induced by appropriate government policies.

314. Other R & D projects include: design of a low-cost still for potable spirits (Akinrele, 1974), production of "soy-ogi" (a protein enriched food), vegetable oils, ceramics, low-cost dryers. The gari, ogi, and still projects are (in the process of) being commercialized.

TABLE 7 Research carried out at the EAIRO during 1942-1947.

product	raw materials	commercial production
aluminium sulphate	clay	yes
caustic soda	lime and sodium carbonate	yes
cement	pozzuolana clays	
copper sulphate	malachite	
glass	sand	yes
paint	barium sulphate	yes
lead (for pencils)	graphite	
phosphatic fertilizers	(not using sulphuric acid)	yes
building board	groundnut shells, sisal,...	yes
domestic pottery	clay	yes
adhesive	latex	
insecticides	pyrethrum	yes
khaki dye	plant extraction	yes
totaquina (anti malerial drug)		yes
beer	barley	yes
nicotine sulphate	tobacco waste	
soaps	shea butter and others	yes
driers (for paints)	vegetable oils	yes
creosote	wood	
charcoal	bagasse, cassave stalks	exists
acetic acid	molasses (fermentation)	yes
citric acid	bitter oranges	
brake fluid	castor oil	yes

could not compete with imported products. This illustrates two things: Firstly, as was noted in section 3.4 on indigenous technology, that many production systems (possibly appropriate) could be realised, but are never done so in the given economic context. Secondly, even those that are economically possible are not always realised. (That is to say, the three production systems that survived owe their existence to the war.)[318]

315. In view of the prospects of the East African Community the future of the EAIRO may be tricky.
316. The information in the tables is based on EAIRO (1970), recent annual reports (EAIRO, 1975) and personal communication. The tables do not include all research, but only those projects that bear on the class of chemical production systems as delineated in the next chapter. The indications 'exists' and 'in use' imply that the production systems existed or the machines were in use before the EAIRO started research on them. A much more detailed analyses would be necessary (and interesting) to asses what contributions the EAIRO has in fact made to the economic viability of the production systems concerned.
317. See on the soap industry in Kenya note 233 and section 5.4.2.
318. Of course, during the war the staff of the EAIRO was British and the Organisation still employs expatriates. I am not arguing that people without any technical or scientific training can set up and run an oil refinery, if need be. The point is that any group of people can do more than seems apparent from what is actually done. Cf section 3.4.

TABLE 8 Research carried out at the EAIRO in the period 1946-1976

product	raw materials	commercial production
barium carbonate	barium sulphate and sodium carbonate	
blackboard chalk	soapstone	
cement	pozzuolana lime	
bleacher agents	earths	
sodium silicate	diatomite	yes
plaster	gypsum	
lead (for pencils)	graphite	
S-based chemicals	sulphur	
bricks, tiles	earth, gypsum	exists
adhesive	tannin extract	
hecogenin (steroid)	sisal	yes
other drugs	sisal, aloë,...	
papain (enzyme)	paw paw	
essential oils	22 plants	
edible oils	oil seeds	exists
other oils and waxes	advocado, bagasse, sisal,...	
dyes	anatto,...	
resins (phenolic)	cashew shell liquid	
beer	various	
citric acid	molasses	
alcohol (spirits)	cashew apple, molasses,...	
methane	sisal waste,...	
furfural	various wastes	
paper	papyrus,...	
particle board	various wastes	
charcoal	bagasse, cassave shalks	exists
fibres	bananas	
milling machinery	cereal	in use
dryers	coffee, pyrethrum, groundnuts,..	in use
bean sorting machine	coffee	yes

The three production systems that have been brought to the stage of commercial production after the war illustrate another point: the products are produced by foreign firms. The most recent succes of the EAIRO, the bean-sorting-machine which separates the one per cent or so "rotten" beans from the coffee - a major innovation, is now produced and licensed by a British firm.

4.3.2 University based centres.[319] According to the old look universities should form a bridge to local industry, for example by providing consultancies. According to the new look they should establish "techno-

319. See on activities of universities related to education chapter 6; the research programme on 'appropriate chemical technology' at the University of Mexico and the activities of the *Asian Institute of Technology* are also described there (see notes 518 and 522).

logy consultancy centres", "appropriate technology units", or similar to cater for local needs.[320] In this subsection I describe in some detail one of the first centres of this type[321] and a class of centres in South-East Asia that operate on the boundaries of the old and the new line.

The *Technology Consultancy Centre* (TCC) at Kumasi (Ghana) was established in 1972 at the Kumasi University of Science and Technology on the initiative of ITDG.[322] 'It seeks to upgrade existing craft industries such as textiles, pottery and woodworking by the introduction of new products and improved manufacturing techniques and it endeavours to generate new small-scale industries based on products developed in the Faculties of the University and utilising, as far as possible, locally produced raw materials.' It employs about 50 people and its main activities have been the development and commissioning of small soap and caustic soda plants, the establishment of a steel-bolt production unit and the development and manufacture of a wooden broadloom.[323] In 1975 the "Ashanti Villages Craft Development Project" was started.

The TCC is probably the "appropriate technology" unit most often quoted. In publications and lectures given all over the world by ITDG-affiliates the importance of TCC-Kumasi is always stressed. At present, however, the output of the centre in terms of created employment or turnover is still in no proportion to the input.[324] Reliable information of what has happened since 1975 seems impossible to obtain[325] - although I visited the centre in August 1976. However, what is happening is certainly not what has been suggested in lectures commissioned by ITDG.

320. It is to be expected that such centres will also be established in the industrialized countries. For example the Newcastle Polytechnic and Delft University of Technology are considering the establishment of such centres, whereas almost all overdeveloped universities now have informal working groups promoting such ideas.
321. Organisations similar to TCC-Kumasi have, inter alia, been established at the University of Zambia *(Technology Development and Advisory Unit*, 1975), at the Indian Institute of Science, Bangalore (ASTRA-cell, 1974) and proposed for Mauritius (Dickinson, 1974), Tanzania (ITDG, 1975). See further the announcements in VITA-News.
322. TCC-Kumasi (1975). See also Powell (1974) and DSE (1972, pp. 121-139).
323. Also a small process plant for making spider glue and various consultancies are mentioned. Within the respective faculties there are production units for ceramics, cement building blocs, traffic lights and electric motor rewinding. However, interest of staff-members of the university in the activities of the Centre is still minimal.

Regional Adaptive Technology Centers (RATC) are located at Universities in Thailand, Indonesia, and South Korea. The idea for these centers was launched in 1972 by the *East-West Technology and Development Institute* in Honolulu (Hawai). With further support of the IDRC the centres were established around 1975. 'The RATC shall look towards the development of industries, particularly the small and medium-scale types where more people could be employed, through researches in adaptive technology, through a logical and integrated regional development pattern of such industry development, and through the motivation and enhancement of necessary entrepreneurial talents.' The philosophy behind this is 'the concept of inducing development utilising the four-focal thrusts of employment as goal, adaptive technology as means, entrepreneurship as agent, and public policy and institution building as framework for development.'[326] It is the philosophy and the exchange of experiences that should bind the three RATCs - the actual activities depend on the region where they are situated.[327] These activities would have to include R & D[328], training and service activities.

4.3.3 Specialised R & D institutes. Large multinationals usually have

324. Most of the sensible suggestions in Dickinson's report on the 'more specific aspects of the centre in the University and to indicate feasible lines of development' have not been implemented in the first five years of TCC's existence. I have not been able to discover whether this just indicates lack of manpower or wether other factors are involved.
325. I have heard rumours that the soap factories are not working, which, in itself, seems strange, because during 1976 it was often impossible to obtain soap at all in Ghana (as well as many other products, due to severe import restrictions and intricate activities of wholesalers). The broad loom appears to be not feasible in the given economic context. It is said that the large-scale textile producers are able to keep the price of cotton thread high - which thread has to be bought by the village users of the broad loom. The 'Ashanti Village Craft Development Project' looks interesting but has only entered the stage of implementation.
326. Ignacio (1974), the assigned head of the RATC in the Mindano State University of the Philippines. 'Adaptive technology is the process whereby technology from one evironment is transferred to another with due consideration to the latter's indigenous technology. Such transfer of technology must, as much as possible, gibe with the existing socio-economic structure of the region and the cultural practices of the people.'
327. Ignacio (1974). See also the RATC (1975) of the Yeungnam University in Korea who states as its goal: 'develop and execute viable programs for the generation, adaption and diffusion of locally appropriate techno-

special branches in their R & D structures that are involved in adapting production systems to environments in LDCs [329]. Usually such R & D is carried out in industrialised countries; only in very large LDCs such as India do a few R & D branches of multinationals exist. For understandible reasons pertinent information on the activities of these centres (as distinct from the information contained in the speeches of their directors) is difficult to come by. In the field of appropriate production systems there are a number of R & D institutes which are not clearly government- or university-based. I shall briefly describe three of them.

The *Brace Research Institute* at Quebec (Canada) was originally set up to make desert or arid lands suitable for agricultural use. In 1959 a policy decision was made to concentrate on individuals and small communities in LDCs. They became involved in "appropriate technology" because projects in that area are small and cheap, and from 1960 to 1967 they operated research test facilities on Barbados (West Indies). They discovered that: 'Between the identification of an appropriate technology and its succesful application lies the critical problem of cultural adaptation.' [330] By far the majority of their R & D has to do with solar energy: cookers, dryers, pumps, and water distillation.

The *International Rice Research Institute* (IRRI) at Manilla (The

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logy, to foster internal/external conditions conducive to the expansion and development of small and medium industries, to create employment opportunity and income growth for the socio-economic development of specific clientele regions.'

328. The Mindano University intends to engage in ceramics, coconut charcoal, soil cement and brassware. The Yeungnam University has started on projects for the medium and small-scale food, textile, and electronic industries.
329. Probably one of the oldest (15 years) is the "Philips Fabricage-Proefcentrum" at Utrecht (The Netherlands), which is concerned with 'industrial activities in countries with limited possibilities', and has been involved in the investment of 20 factories in LDCs for which production systems were adapted with respect to labour intensity, complexity and length of production line (Van den Brink and Menkveld, 1976). Unilever claims that all R&D concerning their production systems in India is carried out in India (Velthuis, 1976).
330. Lawand et al (1974). See also Hvelplund (1974). Their experience is that in implementing a production system in a small community in an LDC one needs the cooperation of local technologists, local social workers and economists. See for their activities on information exchange section 4.5.4.

Philippines) was established in 1961. Financed from US-AID projects, IRRI has succesfully established an indigenous farm equipment industry by developing a number of low-cost, demand-oriented products which could be manufactured economically with locally available production methods.[331] Their most succesful design is a power weeder, starting production in 1971, by 1974 6000 units produced and by 1976 25.000. Other designs include threshers, tillers and batch dryers.[332] The program has been succesful because it was oriented to both the needs of the farmers and the manufacturers (local metalworking firms).

The *Planning Research and Action Division* (PRAD) of the Uttar Pradesh State Planning Institute (India) has a philosophy similar to the IRRI. It has been active in a wider range of production systems,[333] in particular small-scale sugar and pottery production.[334] It is best known for its sugar plant. It is said that about 1000 of these plants have been installed, but no reliable performance data or economic evaluations exist.[335]

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331. 'Primary objectives of the machinery development program are increasing the income and welfare of small rice farmers and fostering farm equipment manufacturing in developing countries.....Program procedures begin by developing machines that satisfy two major conditions. First, designs must be compatible with the technical and economic needs of small farmers who use them. Secondly, the manufacture and servicing of the machines must be within the technical capabilities of indigenous small and medium-scale machine shops.' (IRRI, 1976). Cf also Khan (1973).
332. IRRI (1975, 1976). By June 30, 1976 in total 64,300 machines had been built by 18 small-scale units in The Philippines and 10 elsewhere. Of the 35 projects, 14 lead to a commercial product.
333. 'It is sometimes stated that given adequate documentation, case studies and surveys, there should be no difficulty in developing appropriate technological models for field application. A decade and a half of thinking all over the world, has, however, produced very few models or package plants. Even these are mostly ancillary types of industrial units which can only be established around a large-scale plant and are thus dependent on the very technology which they propose to replace. Appropriate technology, to be able to generate the advantages which have been postulated, has to be an independent technology. Secondly, when these models are field tested, a lot of gaps - technological and organisational - are found. The Planning Research and Action Division of the State Planning Institute, U.P. (India) has been working in this field since 1955 and has tested under actual field conditions more than half a dozen such ideas; success has only been achieved in two fields.' (Garg, 1975b.)
34. See Garg (1974a, 1974c) and also note 305.
35. See further section 5.2.7. on sugar.

4.3.4 Development Studies. Very many research institutes are engaged in development studies. Their research is mainly, outside the scope of this report, apart from two categories: (a) research projects on the choice of products and production systems, and (b) evaluative studies of (rural) development programmes when such programmes were concerned with production systems. In this section I describe the four institutes whose publications have contributed most to this report.[336]

The *Science Policy Research Unit* at the University of Sussex was set up in 1966. In 1976 it had a staff of 39 plus 8 visiting fellows and 14 post graduate students. It is financed for 85% from external sources. 'The primary aim of the Unit is to contribute through its research to the advancement of knowledge of the complex social process of research, invention, development, innovation and diffusion of innovations, and thereby to a deeper understanding of policy for science and technology.' Although small, the Unit has been influential in changing opinions on S & T policies for and in LDCs. Through its field work, mainly in Latin America, Kenya, and Thailand, and through its publications,[337] it has been one of the major forces in undermining the traditional view that LDCs need the same S & T infrastructure as the industrialized countries and the widespread belief that LDCs can simply "import technology from the shelf". Through one of its directors it played a major role in the establisment of the IDRC in Canada (see section 4.1).

The *Institute of Development Studies* at the University of Sussex (IDS-Sussex). Like the SPRU, the IDS was established in 1966, to be a national British centre 'concerned with Third World development and with the relationships between rich and poor countries'. The total re-

336. Other institutes of which a number of publications have been quoted in this report include: the Economic Research Bureau of the University of Tanzania and the Afrika Studienstelle of the *IFO-Institut für Wirtschaftsforschung*.

337. Research projects include: choice of techniques and directions of technical change (Cooper, 1974), the role of machinery supply in the transfer of technology, transfer of technology to manufacturing industry in Thailand (among these: silk production, tin cans, rubber and tapioca processing industry), choice of techniques in the manufacture of tin cans in Kenya, Tanzania and Thailand (Cooper et al, 1975), modern and traditional technologies for rural development (only references have been given that have been quoted elsewhere in this report, see in particular sections 1.6 and 2.2).

search staff attached to the institute is about 100 of which about 20 are overseas at any one time. Two thirds of the Institute's finance is provided by the British Ministry of Overseas Development. It organises study seminars for administrators from LDCs and others and has a large library which concentrates on publications from poor countries and from more obscure sources.[338] As far as this report is concerned the interests of the Institute are similar to those of the SPRU. The Institute played and plays a significant role in the ILO missions and the World Employment Programme (see section 3.1), and more recently also in UNCTAD activities. The so called "Sussex Manifesto on Science and Technology Policy" formed the basis for the World Plan of Action (UN, 1971) and is incorporated to a large extent in the "New International Economic Order".

The *Institute of Development Studies* at the University of Nairobi (IDS-Nairobi). This is a typical example of the large relatively active development studies institutes in LDSc. It is mentioned here because in this report there are many references to publications of IDS-Nairobi.[339] The interest of the Institute in production systems per se is however very limited.

The *David Livingstone Institute* (DLI) for Development Studies at the University of Strathclyde Glasgow (Scotland) employs about 10 economists and engineers all engaged in detailed studies of the range of choice available in a number of production systems such as sugar, footwear, and urea.[340] Detailed information is gathered on virtually all existing production systems for a particular product and tools and machines used in the system. By distinguishing all the different unit operations in existing processes,possible production systems are identified that are not in use, but could be used given the available market in machinery.

338. IDS (1976). Publications of IDS-members, referred to elsewhere in this report, include Singer, Vaitsos, Kaplinsky (1974 ab), Epstein (1975), Lipton (1974), Cooper et al (1975).(Cooper is joint member of SPRU and IDS.) Research projects include: transfer of technology to Kenya, Ethiopia, Latin America, and other countries; and the Village Studies Programme as part of which various bibliographies are produced.

339. Publications of IDS-Nairobi include: Burke (1973), Ghai (1974), Godfrey (1973): Harper (1974), IDS-Nairobi (1972, 1973), Lele (1974), Mazrui (1975), Rastad (1969), Tobin (1974).

340. See table 5 for other projects and publications.

The choice of product (e g for beer and sugar) is given some attention. Due to the very detailed analysis of the processes there is a tendency to get lost in evaluating the data (or maybe even in the computer programme) and the risk that the results are interesting but rather abstract.[341]

4.4 Agents of change

4.1.1 Rural development. There are thousands of different organisations involved in rural development programmes. Most of them are based in industrialized countries and they fall roughly into "establishment" and "concerned volunteers" categories. I shall present here only two LDC-based organisations which are representative for the new look.

The *Sri Lanka Jatiko Sarvodaya Movement* at Colombo started in 1950 and draws its inspiration from the Gandhian philosophy. Today it is working in more than 500 villages. Their concern is 'Without destroying the existing social tissue, it seeks to implant the best of scientific and technological advances in response to the hopes and aspirations of the people whom it seeks to serve.' The emphasise is on training programmes 'for selected youth for both leadership and for acquisition of technological skills.'[342]

The *Ghana Rural Reconstruction Movement* (Gh RRM) is a non-political, non-religious and non-profit-making organisation[343] established in 1972 'by a few civic-minded Ghanaians who are concerned about the plight of the under-privileged, long suffering and poverty-striken rural population which constitute about 70 per cent of Ghana population.'[344] Their main project is a so called "social laboratory" covering an area of a-

341. Publication of the results is rather slow. In a special issue of "World Development" (Sept. 1977), a presentation is given of the progress made so far. There seems to be a problem in interpreting the data for sugar, or, at least, publication policy is confusing: see note 441 on sugar.
342. Quotations from De Silva (1974). More recently the Sarvodaya Movement has become engaged in cooperation projects involving the standard subjects (agricultural tools, windpower, biogas).
343. GhRRM is affiliated with the "International Institute of Rural Reconstruction", established in 1952, based on the philosophy of Dr Y.C.J. Yen. There are similar organisations in Formoza, Thailand, the Philippines, Columbia and Quatamala. The existence of a cold war off-spring is still recognizable.

bout 25 square miles in Mampong valley with a population of about 3370 spread over 22 villages. The normal rural development activities are covered. Of interest is the detailed record that is kept of the process of change and the rather succesful approach of respect for the farmer's intelligence, ambition and traditions followed by the integration of larger groups of people.[345]

4.4.2 Cottage and village industries. Many rural development programmes, usually concentrating on agriculture (tools, methods, water) and health, are carried out by foreign or private indigenous organisations. This is not the case with programmes to help and upgrade the smallest-scale production systems. These programmes are almost without exception fully implemented by government agencies (to which, of course, foreign advisers may be attached). As has already been described in section 3.2.4 the experience in India with these types of problems is vast. I describe here the organisationsof this kind best known for their appropriate production systems interest.

The *Khadi and Village Industries Commission* (KVIC) at Bombay (India) was set up in 1957 - other government agencies being involved in similar tasks before. The word "khadi" refers to hand-spun and woven cloth, that was heralded during the days of the struggle for Independence as the "Livery of Freedom." The Commission is concerned with about 25 cottage industries[346] and deals 'with purchase and stocking of raw materials, production of goods and commodities, designing of tools and instruments and manufacture and supply thereof, technical advice, training etc.' The KVIC is a large organisation, employing about 4500 employees of which about 50% technical cadre. KVIC has produced various technical innovations for rural industries, e g a power operated "ghani" (for oil pressing) and improved lime kilns. But it is also promoting

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44. (GhRRM, 1976) Their motto is 'Go to the people. Live among them. Learn from them. Serve them. Plan with them. Start with what THEY know. Build on what THEY have.' See also Gyasi and Quarcoo (1977).
45. For example: in two villages without a chief, one has been installed; people of different villages cooperate in clearing the communal road.
46. For this report the following are relevant: processing of cereals, gur and khandarsi (sugars), palm products, Ghani-oil, non-edible oil and soap, manufacture of cottage matches, hand-made paper, lime, pottery, gum risins, shellac, methane gas and manure from cowdung.

production systems - e g biogas plants - for more than a decennium without there ever being improvements made based on subsequent experience or development work. Basicly KVIC is active in protecting a declining and threatened section of the economy.[347] It is not capable of significantly upgrading the khadi- and villages industries. Although KVIC seems to be rather bureaucratic, the basic problem has, of course, more to do with the general socio-economic structure than with the specific capabilities of KVIC.[348]

The *Small Industries Development Organisation* (SIDO) at Dar es Salaam (Tanzania) was established in 1973, succeeding the National Small Industries Corporation of Tanzania.[349] SIDO was established on the advice of Indian Government and on the basis of local needs and policies. It is 'responsible for planning, coordinating, promoting, and offering almost every form of service and technical assistance to small-scale industries on a national level.' It has about 20 regional offices for extension services and contrary to organisations with similar names, it is directed to rural development: i.e. village industry.

347. In India there exist lists of products for exclusive production in the family and small-scale sector and for exclusive purchase by the government from this sector. The first list includes bichromats (except for exports); azo and basic dyes; fireworks; laundry soap; paints and varnishes (e g red lead, aluminium and graphite paints, all paste paints); palm rose, cashew shell and pine oil; most plastic processed products; tooth paste; zinc oxide; sodium, potassium, and calcium silicate. The second list includes: boot and French polish, copper sulphate, plaster of Paris, shellac, hand presses, paint remover, benzol benzoate, polythene film. Many items on the second list, e g safety matches have added 'except for defense'.

348. An organisation with similar tasks is the *Industrial Development Board* (IDB) of Sri Lanka, set up in 1972 as the main promotional agency for the development of small industries. 'It is helping to set up small scale units for the manufacture of straw board, matches, laboratory glassware, tractor trailers, starch from manioc (cassava), banana fibre etc.' They also operate workshops that produce machinery for these units.

349. This organisation, a subsiduary of the *National Development Corporation*, was founded in 1965 to promote cottage industry as well as small-scale industry and to improve the working conditions of artisans. It has been mainly engaged in setting up workshops for artisans. See Livingstone (1970) for an early evaluation. See for an early evaluation of SIDO: Müller (1974). There exists also the *Tanzanian Agricultural Machinery Testing Unit* (TAMTU), which manufactures a wide range of animal-drawn farm equipment and develops do-it-yourself techniques for villages. See on this type of village mechanisation Mac Pherson (1975), who has been working for TAMTU.

However, communication with the regional offices is difficult and processes of change in villages do not happen rapidly and easily.

SIDO is not itself engaged in development or construction work, only in the promotion of production methods and systems that have proved their mettle elsewhere. This seems to be a good philosophy and it is doubtful that SIDO would benefit much from cooperation projects with institutions from overdeveloped countries, which would easily alienate SIDO from its major task.[350]

4.4.3 Training and extension. Under this heading come the many traditional institutions that have been set up to cater for the needs of the small- and medium-scale industry - very often only for the urban industries.[351] The scale of industries on which they concentrate varies according to local circumstances, but in general it favours the larger modern small-scale industry[352] because of its greater profitability. All these institutions seem to have very conventional economic ideas,

350. The same applies to the other LDC institutions that - with the new look - have become fashionable to cooperate with. It may of some interest to note that (i) Mc Robie from ITDG writes in 1976: 'The current SIDO programme, for which it is seeking both technical and financial assistence, includes ...', and (ii) I have heard in 1977 at least one European R & D institute stating that they are corporating with SIDO in a field project - whereas SIDO informs me that 'Not many foreign R & D institutions are working in the country - in fact none at all through us.'

351. There are, of course, also many training and extension services for agriculture. They fall outside the scope of this report, because of their general lack of interest in post-harvest technology. One of the more well-known and rather succesful organisations is the *Institut Africain pour Développement Economique et Social* (INADES), established in 1965. It is basicly concerned with the training of peasant farmers. The core of the system is a system of correspondence courses and seminars (124 in 1976). Each group/village taking part in the course is visited each month by the INADES extension service. It is assumed that 'There can be no long-term increase in agricultural production unless peasant farmers are given proper theoretical instruction and are allowed to assume responsibility for their own development.' (Dubin, 1974). 'We have to tailor the contents of our courses to the technical level of present-day peasant farmers and to what they can be offered in the light of their ability to assimilate agronomic, economic and sociological matters. If a particular form of technology is recommended in a course, the assumption is that it is technically feasible, profit-yielding and suitable for widespread application having regards to the knowledge and awareness of the people to whom we address ourselves.' INADES-formation now covers 19 African countries and has 9 regional offices. Their courses have been translated in seven African languages and are used inter alia, in the Philippines, Indonesia and Brazil.

concentrate on training and helping entrepreneurs in getting capital and/or workspace, while the technology is just taken from old handbooks.[353] The only institution that displays some wider perspective is SIET (see below). The following four institutes should provide a representative sample:

The *Office pour la Promotion de la petite et moyenne Entreprise Ivoirienne* (OPEI) at Abidjan (Ivory Coast) participated over the last fouryears in the establisment of 150 enterprises creating 1500 jobs. However, they have their luxury offices in the centre of Abidjan and only advise entrepreneurs who come to them. The staff of the office is not interested in rural industry because 'it does not pay' and is so to say, not aware of the existence of any other parts of the world besides Abidjan and Paris.

The *Kenya Industrial Estates Ltd.* (KIEL) at Nairobi was established in 1969. It has concentrated its efforts in providing working areas, capital, and courses for starting entrepreneurs. They claim that they have been succesful in "saturating" the market for the simplest production systems (repair shops, etc.). Recently they have directed their attention to a more advanced scale (producing simple consumer goods). The main problem for this further development is the lack of basic technical education and the problems involved in obtaining information on appropriate production systems. Opinions on the succes of KIEL differ. Probably, they have been quite succesful - within the boundary conditions set by the larger foreign owned or operated firms in Kenya.

The *Small Industry Extension Training Institute* (SIET) was established as a "Government of India Society" in Hyderabad in 1962 'to assist the promotion and modernisation of small industry.' Its main function is providing training programmes, also for trainees of other developing countries (about 50 courses each year). Other tasks include: providing consultancy services and dissemenation of information on small in-

352. 'Yes, we have also courses for small entrepreneurs. We teach them how to become bigger.' (T.O. Odufuwa, Lagos Area Officer of the Industrial Training Fund, Nigeria.) (All enterprises in Nigeria which employ more than five people pay an obligatory contribution to the Fund.)

353. I shall not deal with the very many organisations in industrialized countries that organise training courses for entrepreneurs and technologists on a more advanced level. See for a description of a number of organisations: Bass (1976).

dustries.[354] About 40 reports on various aspects of small industries and rural industrialisation have been published.[355] As mentioned in section 1.2.2 it organised in 1964 the first conference on "Appropriate Technologies for Indian Industry".

4.5 Institutions in the linkage area

4.5.1 Organisations transferring hardware. In this category it is useful to distinguish three subclasses:

(a) Institutes providing services in trouble shooting, industrial design, quality control and other consultancies when requested by small-scale industries.[356] Most of the R & D organisations mentioned in section 4.3 carry out such services if asked. In India all major institutes of science and technology have "Industrial Research and Consultancy Centres" that undertake assignments for industry. Most universities in LDCs provide some services in the area of quality control. It is clear that these services already presuppose the existence of viable industries that ask for such services. New-look aspects are

354. The "official" organisation is the *Small Scale Industries Development Organisation* (SSIDO) established in 1954 following the advice of an international mission of the Ford Foundation. SSIDO operates through 16 branch institutes and 45 extension centres. As I remarked already in note 302 it is not very clear to me to what extent the responsibilities of all these organisations overlap. Probably a number of the organisations (like those in the UN-family) have as their major goal to survive within the budget.

355. For example SIET (1972), Chebbi (1973), Christopher (1974). It also publishes the Appropriate Technology Documentation Bulletin (see note 377).

356. See Bass (1976) for a description of a number of organisations in LDCs specially established for this purpose. One of the more succesful organisations - in an environment of vast expanding industries - is 'The Singapore Institute of Standards and Industrial Research (SISIR), with a professional and technical staff of 207, an annual budget of S$3 million, providing services in standardization and quality control, mechanical/civil engineering, chemical technology, instrumentation and process technology, technical information, industrial design, materials science, electrical engineering and environmental control. It now earns some 55% of its income from fees, and in 1972 carried out some 7,000 cases of technical and consultancy services to industry. The Quality Certificate Scheme begun recently and now superceded by the SISIR Marking Scheme has been a stimulus to upgrading the quality of manufactured products for the local and export markets. Today, more than 200 different brands of products bear the SISIR Mark.' (Bass, 1976).

therefore rare in this area.

(b) Sellers of small-scale apparatuses. Of this type, there exist of course thousands of commercial organisations, in particular in the industrialized countries. The need for these items in developing countries is filled from four different sides:

(i) Ordering from standard catalogues. Most technical aid programmes use this system. Under the influence of the new look, practice is changing from ordering the best (i e most modern) to using old catalogues.[357]

(ii) Buying units that have been designed specially for use in LDCs, usually by multinationals and occasionally as the outcome of the R & D activities of central research organisations.[358]

(iii) Buying units from Japan where a large number of organisations sell small and medium-scale production systems that were developed for the Japanese small-scale industry. Examples are the *Japan Consulting Institute* (JCI) which sells more than one hundred mainly medium-scale production systems[359] and the *Cecoco Agricultural and Small Industrial*

357. FAO, personal communication. Most UNDP missions still use rather new catalogues.

358. As early as 1959 UNIDO stated: 'Much more important possibilities of substitution may emerge from appropriate studies of the basic production processes themselves. If carried out by producers of equipment this would require a certain reorientation of their present research in design; in fact, in many cases it would run contrary to the present tendency in design research which aims largely at economy in the use of labour. It was mentioned that the research might be carried out advantageously by public and private technological research institutes, both in the developed and underdeveloped countries. Moreover, it might be of considerable importance for the possibilities of industrial development in underindustrialized areas if producers of the equipment currently demanded in those areas would orientate their research towards designing types of equipment for optimum performance at capacities lower than are normal in the highly developed countries. By thus reducing the minimum size at which industries could be economically established and operated under conditions of generally limited domestic markets, the process of industrialization in its earlier stages would be greatly facilitated.' But this analysis has not led to any particular action I know of. Because markets in LDCs are small, the interest of equipment producers is only in expanding their sales of equipment designed for the home market.

359. In chapter 5 a number of these processes are referred to. No data are available giving information as to whether these processes are anywhere in succesful operation.

Centre, established in 1916 and selling hundreds of small machines.[360]

(iv) Buying units from the more technical advanced LDCs such as India and Brazil.[361] Over the last few years there seems to have been a steady increase in this trade, in particular from India to East Africa.

(c) Transfer of R & D to industry. In section 2.3.1 some remarks were made on the ineffectiveness of central research institutes in doing appropriate R & D and having it actually implemented. Very often institutions in the linkage area simply do not exist. Even if they exist not all problems are solved as is shown in the case of India, which because of its size has an enormous R & D potential:

The *National Research Development Corporation of India* is a government owned non-profit organisation established in 1953 and is charged with the responsibility of developing and transferring technology from about 150 R & D institutions to industries. About 700 processes have been licensed by NRDC, of which, it is said, about 50% came into commercial production.[362] In table 9 a selection is given of the (chemical) production units that have been developed. Almost all processes that have been developed are appropriate in the sense of being (rather) low-cost and using only locally available raw materials and machinery that can be produced in India. Although a number of these processes are now commercially applied, it is certainly not a great number. It would be interesting to know, and most useful for other LDCs, what the major reasons would seem to be for this rather meagre return on investment in R & D: Is the technical efficiency of the systems no good ? Are no competent entrepreneurs and or technicians available or prepared to operate the system ? Are the systems just not feasible in the given economic context ? And further: Who benefits from the processes that have been applied ?

TABLE 9 Examples of chemical processes and apparatuses licensed by NRDC-India

production system	raw materials	scale	complexity	developed by
potassium schoenite	marine mixed salt	medium	workshop	Central Salt and Marine Chem.Res.Inst.
oxalic acid	saw dust	medium	India	Regional Res.Lab. Jorhat
menthol	mint oil			Regional Res.Lab. Jammu
bromelain	pineapple waste	small		Regional Res.Lab. Jorhat
citronellol	eucalyptus			Regional Res.Lab.Bhubanechwar
nicotine sulphate	tobacco waste	medium	LDCs	National Chemical Laboratory
high proteïn flour	cotton seed	large	advanced	Regional Res.Lab. Hyderabad
active carbon	shells, husks	medium	India	Regional Res.Lab. Hyderabad
oil reclamation	various	small	India	Indian Institute of Petroleum
paraffin wax	waste Fuller earth	medium	India	Regional Res.Lab. Jorhat
masonry cement	lime and portland	small	workshop	Central Building Res. Inst.
building bricks	paddy husk	small	workshop	Regional Res.Lab. Jorhat

4.5.2 Establishment dealing with queries. Almost all major UN and other overdeveloped organisations concerned with production systems in developing countries provide query-answering services. The largest suppliers of technico-economical information are most probably TPI (see section 4.3.1), FAO and the next two organisations:[363]

The *UN Industrial Development Organisation* (UNIDO) at Vienna operates an Industrial Inquiry Service, which has dealt with some 16.000 inquiries until now. They publish "Industrial Development Abstracts" and "Guides to Information Souces." Processes or equipment that may be suitable for LDCs, in particular those offered by other LDCs, are mentioned in the monthly UNIDO-Newsletter.[364] Following the decision at the Lima-conference on the 'establishment of an industrial and technological information bank' an increase of these activities may be expected.[365]

The *Society for International Development* SID operates a "development reference service" which 'provides elements of reply to questions received from developing countries or on their behalf, concerning all economic and social development fields, with the exception of industrial issues which are the responsibility of UNIDO.' The reference service was created by the OECD in 1965 and transferred to SID in 1973.

360. Typical examples are hand chalk or candle making machine, oil expellers (30-100 kg seed/hour), charcoal kilns, soap making plant, plastic processing machinery.
361. Cf also section 4.3.3 on the IRRI.
362. In Indian journals such as Chemical Age of India, Industrial Bull., Seminar Reporteur, Chemical Industry News, Economic Trends, and Invention Intelligence, R & D is reported on many more industrial processes adapted to the Indian environment.
363. Mention should also be made of the WHO *International Reference Centre* for Community Water Supply. The IRC is engaged in information exchange and R & D coordination on all aspects of water supplysystems. The Centre operates a network of 31 collaborating institutions. Starting with a conference on the subject in 1975 the IRC adheres to "appropriate technology systems", which implies that 'The objective is to establish good, workable systems which provide a regular supply of drinking water; and in doing so, to allow increased participation of local populations in the setting up and maintenance of these systems.' (WHO-IRC, 1977, p. 13.)
364. In 1975 a kind of newsletter containing 'comparable equipment and technologies from developing countries', and 'recycling technologies' appeared as an off-shoot of their activities on 'the collection and dissemination of information on industrial equipment manufactured, and technologies evolved or adapted, in developing countries.'

SID is a private organisation which has 6000 members, mainly persons engaged in programs of international development, and is financed further by a large number of institutions (in particular banks).

4.5.3 The new look. There have always been voluntary organisations which dealt with queries from field workers in LDCs - in the distant past mainly missionaries. With increasing numbers of private voluntary organisations in development,the market for these type of queries is increased and is catered for by a number of now rapidly growing organisations that are usually also active in promoting the idea of appropriateness. The oldest, and by far the most influential, is ITDG, already often referred to in previous chapters. A description of the major organisations in this field follows.[366]

'VITA, *Volunteers in Technical Assistance* is a non-profit private organisation dedicated to providing technical assistance to developing countries and rural areas within the United State.' It was established in 1959 and now has a budget of about $ 600,000, of which US-AID pays 45%. It deals with about 1200 requests a year ("Do you know a commercial use for the copious supplies of seaweed that grow here ?",

365. According to the report of the executive director on this matter (UNIDO, 1977h) a pilot operation of the bank will concentrate on iron and steel, the fertilizer industry, agro-industries, and agricultural machinery and implements. Work in the initial phase would consist of the collection of in-house information, negotiations with international sources and the development of co-operative programmes ..., the establishment of a network of information sources, the preparation of technological information profiles and manuals and the dissemination of information.' Funds are however limited, $US 300,000 for two and a half years. In 1977 a "Development and Transfer of Technology Series" was started, and two issues appeared (UNIDO, 1977 fg).

366. Smaller organisations include: TOOL at Amsterdam (The Netherlands) established in 1976,coordinating a number of working groups at universities. It has a set up rather similar to ITDG. In 1976 TOOL dealt with 500 technical requests and is now engaged in two large-scale consultancy projects for appropriate production systems. They publish a journal "vraagbaak", formerly published by Agromisa (Wageningen Agricultural University), in which some of the answers to technical queries are published. See also section 3.1.7. The *Commission on the Churches'Participation in Development* (CCPD) of the "World Council of Churches" has a technical service unit, whose aim is 'to channel requests for assistance to appropriate sources. Emphasis is being put on education and the participation of people in their own development; stimulating people to achieve self reliance and liberation from oppressive sources.' For this purpose they have produced about 125 leaflets.

"Can I make soap out of locally available materials ?") and sold about 10,000 manuals in 1976 ("Smoking Fish in a Cardboard Smokehouse", "Handpumps for Village Wells", "Chalk Stick Making", etc.). Its main publication is the "Village Technology Handbook." To answer the requests, it is in contact with 4500 (or 2000 or 6500) volunteer experts of which 500, are outside the United States. Counterparts of VITA have been established in various Latin American countries.[367]

The succes of VITA is based on arranging a direct contact between an individual having a problem and somebody who can help. VITA deals with requests, not with appropriate production systems.[368] In fact, the "appropriate technology" philosophy was only adapted in 1975.

'The *Intermediate Technology Development Group*, London, was established in 1965 to investigate ways and means of utilising to the fullest extent the resources available to developing countries through the application of the appropriate technologies.' ITDG via its "guhru" Schumacher, is the most well-known organisation in the "appropriate technology" movement. ITDG publications are conflicting as to what are the major, more specific, goals of the Group. In practice their activities can be summarized as follows:[369]

(a) promotion of the idea of "intermediate technology", by publications and through lectures given all over the world (mainly by Schumacher);

(b) assembling technical information suitable for rural areas in LDCs via its 200 panel members and 3-5 technical officers, usually as a result of technical queries received;[370]

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367. Dominica, Honduras, Guatemala, El Salvador, Nicaragua. At present VITA is assisting in establishing "appropriate technology units" in Upper Volta and Botswana.
368. To a small extent VITA is directly involved in developing production systems. Major projects are at the moment: wood waste utilization, lime kiln (cf section 5.4), and traditional salt at VITA-Honduras; coir extraction in Brazil; ricebran, sugar cane, and oil seed processing in cooperation with a Pakistan consultant firm.
369. See for a summary of ITDG activities for example Mc Robie (1976) and also its well-known "Appropriate Technology Journal".
370. Technical enquiries on chemical units include: furfural (small-scale), detergent from berries, chalk making, potassium chloride, salt from plants, Haber process (small-scale), products from seaweed, lignines and adhesives from wood pulp. See also table 11.

(c) communication of such information to LDCs through personal contacts and its publications;[371]

(d) identifying medium-scale production systems for specific environments by making feasibility studies for LDC governments and getting machine building firms interested in producing small scale machines for LDCs;[372]

At the ITDG offices about 30 people work; they have no large files with technical information - which VITA, Brace and GRET have. All publications, mainly bibliographies and profiles, and most of the queries from oversea are dealt with by the panel members. In table 10 a list of the ITDG panels is given (not all existing subpanels are mentioned). Most panels concentrate on reviewing the state of the art in their field. Because members are often very busy progress may be slow as is illustrated by the data in table 11 for chemical production systems.

With respect to goal (a) ITDG has certainly been quite succesful. With respect to (b) - (d) I am rather pessimistic. Their major output is publications. These publications are sold mainly to overdeveloped countries. Many of them describe either (possible) production systems on a rather abstract level, or give designs that have never been tried out in practice, or contain no information at all as to when such a production system would be economically feasible. It seems to me that often publications are issued to early: what the authors, or a techni-

371. Also more recently ITDG started a UK "intermediate technology" programme (see Davies (1975)).

372. Feasibility studies have been made for Pakistan (ITDG, 1974a), Tanzania (ITDG, 1975), and Guyana (ITDG, 1974b). To make these studies ITDG sends out missions, usually paid by the British Ministry of Overseas Development. Also consultancies on specific projects are made (see Mc Robie, 1976). The Industrial Liaison Unit (4 officers) tries to promote small-scale industries in LDCs in cooperation with firms in Britain. For example, they have been involved in establishing a barbed-wire production unit in Swaziland. Of course, the same firms that have the know-how to help establishing small-scale units in LDCs, also have a market there. Hence, ITDG has to answer them that they won't lose the market. ITDG founded a subsidiary to design and make available small and intermediate scale plant equipment. Until now three plants are on offer (egg trays, candles, glass containers). The leaflets make the same impression as those of the commercial firms offering small scale units (such as HVA, see section 5.2.6).

373. The publications are written by panel members or ITDG's technical officers and then reviewed by the panel.

TABLE 10 Panels of the Intermediate Technology Development Groupe

name	year of inception	publications	number of meatings
agriculture	1970	5 + 45	19
food	1974	-	9 + 4
forestry and forest	1973	-	11
chemistry and chemical engin.	1972	1	32
methane subpanel	1974	2	20
fertilizer subpanel	1975	-	5
building materials	1972	4 + 15	29
cementitious materials	1974	1	18
brick, pipes and tiles	1974	-	11
ferro-cement	1975	1	9
water (treatment)	1969	7	28
power (muscle, solar, wind)	1970	2	3 + 7
transportation	1974	0 + 2	17
homestead technology	1975	-	10
rural health	1968	3 + 12	12
coöperatives	1968	0 + 7	28

TABLE 11 Chemical production systems seriously considered by ITDG-panels

production system (small or medium scale)	bibliography or profile is	actual research is carried out by panel members
milling of cereals	considered (1975)	-
distillation and extraction	in preparation, cf ITDG (1974)	-
oil seed processing	considered (1975)	-
scaling down shaft kilns	considered (1974)	-
cementitious materials		Cambridge
soap making	considered (1976)	-
fertilizers	in preparation (1975)	-
wooddestillation, charcoal	in preparation, cf Drybourgh (1974)	TPI, Edinburgh
chemicals from biological sources	Dalton (1974)	-
dyes	in preparation (1976)	-
sugar	in preparation, cf Pyle (1975)	-
methane	Pyle and Fraenkel (1975)	NCAE,...
pharmaceuticals	in preparation (1974)	-

cal panel, still considers a draft is published in order to increase the number of ITDG-publications.[373] Of course, there are a few best-sellers which clearly satisfy an existing need, but this is not in proportion to the input. As to the credibility of the "intermediate technology" concept, the longterm effect of the quality of the "feasibility studies" that have been made for various LDCs, will be even more desastrous. ITDG has recently changed its policy in that it wants to direct its publications more towards policy makers than towards technology users. I think that is a very good choice.[374]

The *Groupe de Recherche sur les Techniques Rurales* (GRET) at Paris is rather similar in organisation and goals as ITDG.[375] They do not engage in major publications but are producing a "Fichier Encyclopédique du Développement Rural". The "fiches" are intermediate in size between an abstract and a full article and are usually compiled on the basis of one to three references.

4.5.4 Information exchange. At all conferences on appropriate production systems the problem of information analysis, exchange, and dissemination is discussed.[376] Often there is no agreement on what services are needed; most probably this results from the fact that the needs and problems are varied. Firstly, there is the distinction as to the le-

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374. I base this conclusion on the impression I have of the type of people ITDG has available and the fact that the consultancies they had for establishing "appropriate units" (TCC-Kumasi, the Zaria IT-Workshop, and ATDO-Pakistan, see table 6) have been succesful in the sense that something was established.

375. The goals of GRET are ' - établer des contacts avec tous les organismes, groupes ou personnes intéressés par les problèmes de technologies adaptées au développement des zones rurales; - rassambler un maximum d'informations sur ces technologies; - mettre à la disposition des praticiens du développement rural, et en particulier des coopérants français, les informations qui peuvent les aider dans leur action sur le terrein.'

376. See, inter alia, IDS-Nairobi (1973), OECD (1972): 'There was general agreement on some general, not very practical, conclusions. However, there was clear and considerable disagreement on most practical conclusions.'

'It was confirmed during the Workshop that although most of the participating countries were seeking solutions for similar problems in the rural sector, little communication concerning the problem solution approaches existed between the countries. This lack of information exchange proved to be a central problem. There was a great shortage of analyses and data on technologies, procedures, and materials already in use.' (DSE, 1972).

'The private groups consulted during A.I.D.'s April and May meetings recommended strongly that the starting point for an expanded program should be to develop existing sources of informatation about appropriate technology, to encourage more communication among groups active in appropriate technology, and to link them to potential LDC users. Nearly one-third of the action recommendations we received during our April and May meetings concerned the need for better information.' (US-AID, 1976.)

vel one is working at: problems are different for, say, cottage industries, modern urban small-scale industries, large firms, and government agencies. Secondly, on all levels there is a whole variety of different types of information needed. Important categories are:

(a) which options are available to make *this* product;

(b) what is the economic feasibility of these options (in *this* environment);

(c) where and how do I buy an apparatus/factory meeting *these* specifications;

(d) what reliable knowledge is available on *this* subject;

(e) who is presently doing R & D on *this* production system;

(f) who can help to finance *this* project;

(g) who can help me to find out about (a) - (f).

These questions ask for different approaches and different types of people. For example, academic technologists do not understand the significance of (b) - they only can think of appropriate production systems in themselves. Again, most people working for international organisations do not grasp the significance of *reliable* knowledge - for them any information is as good as any other.

Thirdly, there is the variation in communication channels: publications in different forms, use of mass media, gatherings of various types, demonstration projects, personal contacts. The appropriate mixture of channels will vary with level and category of information exchange.

All organisations mentioned in sections 4.5.2 and 4.5.3 are involved in the problems of information exchange[377] and,in particular

377. See on the technical index of the TPI containing about 700.000 entries on about 150.000 sources: Datta (1974). This index is biased to the interests of the research staff, because they supply the additions. See on UNIDO section 4.5.2. The ILO-library in Geneve is well-equiped and reasonably accessible, but contains very little on chemical production systems. The FAO seems to me useless: on the one hand they are either incapable or unwilling to say on what projects they are engaged at a particular moment, and on the other hand project reports are not filed in a central place. See on the *Small Enterprises National Documentation Centre* (SENDOC) of India: Malgavkar and Dutta (1974). See on VITA and Brace: Congdon (1975). VITA has a record of 25.000 completed technical inquiries, but 'there is currently no provision for the evaluation of the responses to enquiries'. As mentioned in section 4.5.4 ITDG does not keep an information system.

over the past few years,many actions are taken to provide better services. VITA, Brace, TOOL, ITDG and GRET are establishing an "informal appropriate technology information network" (ATIN)[378]; FAO, ILO, and UNIDO are all busy creating new or better information banks; handbooks, bibliographies,[379] and newsletters[380] are appearing in increasing numbers. There are however severe problems of scale and quality.

Problems of scale, because (as will be illustrated by many examples in the next chapter) the lack of easily accessible information on small- and medium-scale production systems is enormous. Having somebody working half time here or there on an information system will not do very much. Even more important is the problem of the quality of the information. Of all the organisations involved in providing information on appropriate production systems I do not know of one where a reasonable system of evaluation exists. We shall see in the next chapter that very much of the information that circulates has never been evaluated with respect to scientific soundness and practical feasibility. The problem of evaluation is more urgent than for the establishment literature, because the latter is screened to at least some extent by existing structures (referees of journals, directors of large institutes).

378. A survey carried out by US-AID (1976) showed that most private voluntary organisations used VITA or ITDG; 18 other clearing houses were hardly mentioned.

379. Bibliographies referred to in this report include: Baranson (1976), Auciello (1976), Ganière, 1973 (OECD), TAICH (1975), Bateman, 1974 (ITDG) , Carr, 1976 (ITDG), Dorrow and Pam, 1976 (Volunteers in Asia), UNIDO (1977f). Jenkins, 1975 (Int. Commonwealth Studies). VITA and Brace published handbooks of "appropriate technology". So did Liklik Buk (1977) in Papua New Guinea.

380. "Appropriate" bulletins and newsletters include Appropriate Technology, published by ITDG; VITA-Newsletter; AT Documentation Bull., published by SIET; Small Industry Development Network (SIDN), published by the Economic Development Laboratory, Engineering Experiment Station, Georgia Institute of Technology financed by US-AID); Transnational Network for Appropriate/Alternative Technologies (TRANET); Rural Development Network Bull., published by the *Overseas Liaison Committee* (OLC) of the American Council on Education. 'The Technical Assistance Information Clearing House (TAICH) has been operated by the American Council of Voluntary Agencies for Foreign Service, Inc. since 1955 under contract with the Agency for International Development. It is an information center specializing in the socio-economic development programs abroad of U.S. voluntary agencies, missions, foundations and other non-profit organizations.' It publishes TAICH-News.

4.6 Evaluatory remarks

In analysing the activities of those engaged in S & T for development or more particularly in the development and implementation of appropriate production systems, all critical or evaluatory remarks can be reduced to the fact that "the questions" (see section 1.1.1) and "the stages" (see section 3.4) are not dealt with fully. More specially the problems of many of the institutions described in this chapter (and section 3.1), in particular those that emphasize the "new look" in their policy, can perhaps best be summarised as follows.

(a) A lot of (isolated) activities on the research and (prototype) development of appropriate production systems take place without any contact with the potential area of application. Apart from their isolation, centres of research usually lack (i) (small-scale) industrial experience (entrepreneurial aspect), (ii) feeling for cultural barriers that are encountered in introducing new/other production systems (process of change aspect).

(b) As in other areas the awareness of each other of institutions working in closely related fields is limited.[381] This is not only the case for institutions located in the same city. This seems to be due mainly to the many unco-ordinated UN- and bilateral programs. In particular the lack of knowledge of UN-officials on other UN-projects than their own is striking.

(c) Opinions "in the field" differ considerably with respect to the

381. In october 1976 UNIDO organized a meeting of "Selected Heads of Research Institutes" (UNIDO-1977e) to report on the development and transfer of technology. In the conclusions and recommendations the following bottlenecks are mentioned: technological capabilities of research institutes in developing countries, personal contacts (on which succesful transfer of technology depends), lack of information on activities being taken elsewhere, funds. But nothing very concrete is said on what to do about it. Of course the participants advised UNIDO that this type of meeting was very useful and should be held regularly. I don't think these metings are very useful. Usually the kind of people that are selected for such meetings are so busy attending this type of meetings that (i) they are only superficially aware of what is happening at their own institute, (ii) they have no time to prepare original contributions for such meetings, (iii) they have no time for detailed correspondence with similar institutes. Furthermore their position and probably that of the institute is so vulnarable that it is much too dangerous to engage in real exchange of experience.

importance and usefulness of such rather well-known organisations as VITA-USA or ITDG-LONDON. My impression is that the quality of their output is low:[382] in some cases useful, because for the person needing the information there is no other alternative; in other cases useless or desastrous (but that is what the grass-roots are used to anyway).

(d) Very many "establishment" organisations in LDCs have been and are engaged in what is nowadays called "appropriate technology". To me the main characteristic of the new look is that there is no awareness of these activities, let alone that an analysis is made of why these organisations have not been succesful. For example: The *Union of Burma Applied Research Institute* was established in 1954. Four years later - hence 20 years ago - the institute is among other things, working on 'a whole series of paper products from shredded bamboo' and 'has developed a laboratory scale extractor for rice bran oil which looks hopeful.' Also the philosophy is clear: 'Projects in plastics, electronics, ..., and similar areas are too far from the grass roots to merit attention ...' and 'Several exquisible and expensive methods were explored before an Armour Research Foundation specialist pointed out that the same or better results could be obtained by a simple hot water extraction process,' in short 'projects should have quality about them that relates directly to fundamental local needs.'[383] It would be interesting to know what contribution to Burmese development this promising Institute has - after all - made, and why if they were succesful, this idea was not taken up elsewhere.

382. The problem is that "technology" or "economy", or "appropriateness" do not always fit in with one's ideals. At the panel meeting, much of the discussion focussed on sawdust briquetting. Commercial suppliers of equipment for this process informed VITA that sawdust briquetting could only be accomplished by large, sophisticated machinery. Bush thought otherwise, however, and made several briquettes in his basement by compressing sawdust and starch in a piece of plastic pipe, using a broom handle.' (VITA, 1976a) It is possible that the commercial suppliers are wrong. But, how much starch did Bush use; how strong were his briquettes; how did he separate the briquettes from the plastic pipe; did he make a large pile of them; were they actually used for the purpose they were made for?

383. See Beck (1958). Also:'the Union of Burma applied Research Institute has patented a process for the manufacture of cooking oil from rice bran and is currently designing a plant for this new industry. In view of the fact that Burma has so far imported practically all its cooking

(e) Very little is done in terms of systematic evaluation of what the long-term effect is of the various activities. ITDG sells many publications, but it is not known to whom. VITA answers many enquiries, but it is not known what the overall effect is. KVIC promotes the use of biogasplants, but does not know which people have built one and what effects they have had.[384]

(f) No serious attempt is made to evaluate the macroeconomic effects and efficiency of the investment in promoting appropriate production systems. The question is not only: How much real money and "free" time of volunteers goes into creating one appropriate production system , which can and does survive in the environment it was designed for ? It is also: How many units have to be established to have a significant macro-effect in terms of output and employment,[385] and in terms of bringing about a change in the society concerned.

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oil-in 1959, imports amounted to the equivalent of $11,5 million-this development should result in appreciable savings in foreign exchange, (UNIDO, 1963). According to the same UNIDO-publication :'The Central American Technological Institute for Industry has investigated the industrial utilization of bagasse resulting from the distillation of citronella oil and lemongrass oil, of coffee waste products, of yucca for the production of starch etc.' And the *Ceylon Institute of Scientific and Industrial Research* was engaged in similar research. (F.Wijsekera (1976). See also section 4.3.1 on the EAIRO. In a less extreme sense similar examples can be given for research at LDC-universities. For example, it is now fashionable to propose R & D programmes for extraction of drugs from indigenous plants. But numerous LDC-universities have been, at least formally, engaged in such research since their inception It would be intersting to make an inventory of these projects and evaluate the results.

384. Organisations that have long standing field experience all stress that the process of change has to be monitored for many years. Even then: 'The organisation and the resolution of *maintenance of completed projects* has not matched the expected succes until now' (SATA, 1974).

385. Not many new look organisations are worrying about the fact that 'Howver, simple to operate, maintain and organise production may be IT requires that huge numbers of separate units somehow get off the ground. This is unlikely to happen naturally and without considerable organisation and administration in terms of spreading knowledge about the techniques, providing access to capital, to inputs and to markets, This is a type of external administrative complexity that is inevitably involved in any attempt to organise production on the lines suggested by IT. The administration required per unit of output is almost certainly greater than for Western technology.' (Stewart, 1972)

5. APPROPRIATE CHEMICAL PRODUCTION SYSTEMS

5.1 Priorities in research

5.1.1. Chemical technology and basic needs. Depending on one's interest there are numerous ways of classifying chemical or other production systems. In this chapter a number of chemical and related production systems are discussed that are grouped according to something like "basic needs"; those can come under consecutively food, energy, health, shelter, and miscellaneous.[391] This,of course, does not lead to a unique ordering: the same product may be used to fulfil different needs, and products fulfilling different needs may normally be produced in the same system. Three other ways of classifying are briefly discussed in the next subsections: according to raw materials (stressing the use that can be made of available resources); according to unit operations (Stressing the use that can be made of experience, with similar operations in different production systems); according to demand on the market (stressing import substitution and the "service - aspect" of chemical production systems to other systems).

The emphasis in this chapter is on the less-conventional and less-sophisticated production systems. Not much will be found on the production of sulphuric acid or synthetic polymers. It does not follow that these products may not fulfil basic needs. That is to say: this chapter does not list the appropriate chemical products - because a priori any product may be appropriate. If a product is not discussed

391. Other proposed priorities include: R & D (for, and choice of,chemical production systems) should find a proper balance between (i) support of agriculture (fertiliser, post- harvest treatment, waste processing), (ii) import substitution, (iii) export from villages (Reynolds, 1975); (i) post-harvest technology, (ii) use of waste, (iii) scaling-down conventinal production systems (UNIDO, 1977b).

or hardly so, it means that I have found little scope for making the available production systems more appropriate relative to the need of the products in some, or many, of the LDCs. Furthermore, the space devoted to any particular product is a function of the amount of pertinent information I have been able to collect in the short period available.

Although the term "basic needs" has recently been much in use, its meaning tends to be rather emotional and abstract. I would like to draw one important distinction which is relevant for this chapter: Because it will be rarely appropriate to produce all products that are necessary to fulfil the "basic needs" oneself, one needs money to buy those products. This argument applies over the whole range from family to state. Therefore, to some extent, money is a basic need and hence any product that can be sold outside the economic system considered fulfils in some sense a basic need for that system. My opinion is that any appropriate (policy to promote the appropriate) choice of production systems has to balance (i) the "basic needs", (ii) the money-argument, and (iii) the advantages of an indigenous technology.[392] With this in mind, the selection of production systems discussed in this chapter can be explained as follows:

(a) only chemical production systems are included, i e systems whose main task is to bring about physical and/or chemical changes in the materials processed; metallurgy is not included and food technology only partly;[393]

(b) most of the basic chemicals and petrochemicals are not discussed, because it is doubtful whether LDCs should invest in these production systems on the basis of either "basic needs" and/or "indigenous techno-

392. Although, where appropriate, I discuss the labour-intensity, I think chemical as compared with other production systems are always rather capital-intensive. Therefore I do not add as a fourth factor in the balance the "employment-argument". What could be added is the income-distribution aspect. This stresses decentralized processing as far as possible. However, the latter also follows from "basic needs" and "indigenous technology"considerations.

393. I include the following food industries: unit operations in post-harvest treatments, sugar extraction and refining, carbohydrates-processing, vegetable oil processing, alcoholic beverages and salt. Not includedare: meat, dairy, fruit, vegetables, and fish processing; bakeries, confectionery and soft drinks.

logy" (i e if needed they should be imported); whereas on the basis of the money-argument what counts are macroeconomic considerations and bargaining power, i e the appropriate system then, is simply the cheapest.

5.1.2 Sources of chemical products. In the literature on appropriate production systems, it is common to point out that useful or valuable products can be obtained from wastes or other seemingly free resources. Much less attention is given to the fact that so-called wastes are used for some purpose; and secondly the language used often suggests that these valuable or useful products can be easily obtained without need for capital, skills, or other irksome requirements. In the next sections I shall give specific examples of this lack of critical attitude. For the sake of completeness I list here the major sources of chemical products.

(a) Inorganics from deposits. The conventional source of inorganic chemicals is from deposits. Major ones being suphur (for sulphuric acid), salt (for caustic soda, chlorine, and soda ash), and phosphates (for fertilizer).

(b) Petroleum. Apart from being a major source of energy the petrochemical industry is the conventional producer of organic products, with the exception of

(c) Agro-based chemical products. Conventionally: oils and fats, suger, starch, alcoholic beverages. Products outweighed by synthetic production: drugs, insecticides, dyes, pectiine substances,(rubber, sisal).[394]

(d) Coal and wood. Much advocated as raw material substitutes for petroleum.[395] Due to the energy-crisis an enormous R & D on these

394. A useful summary of "Chemicals from biological sources" is Dalton (1973) - a new edition to be published by ITDG in 1977.

395. 'The result of this situation has been to attract growing attention to the industrial conversion of wood waste. From Yugoslavia to Chile, there is scarcely a country which is not planning some new factory for chemical wood utilization....Of course, the new age of wood is still far away, but it is moving nearer with every day. If this book can accelerate this process by showing that the new role of wood in world economy is both necessary and possible, my most ambitious hopes in writing will be fulfilled.' (Glesinger, 1950). The new age may be near now. See Zinkel (1975) and Chang et al (1976) and references given there. See on coal for example UNIDO (1973). It is easily checked by consulting *Chemical Abstracts* how R & D in coal- and wood chemistry is becoming fashionable.

raw materials is now coming off the ground. Given the available resources for this R & D, leading to sophisticated, efficient, systems, there seems not to be much scope for appropriate R & D for LDCs.

(e) Products of the sea. Source of both inorganics (as a by-product of salt production) and organics (seaweed). The first seems only possible on a very large scale.[396] The discussion about the potentialities of seaweed is still hampered by a science-fiction atmosphere.

(f) Products based on organic "waste". This includes a whole range of mainly organic products, partly overlapping with the agro-based products mentioned under (c). It would seem that here is the largest scope for appropriate R & D. However, no easy successes should be expected.[397]

5.1.3 Unit operations. This type of classification is furthest away from the choice of product and the actual operation of production systems. It has however certain advantages, which follow from comparing similar unit operations in different production systems. Usually the more fundamental the R & D needed, the stronger the cause is to organize it according to unit operations.

The major unit operations that will be discussed in this chapter are: mechanical extraction, physical extraction, distillation, drying, and fermentation. Other important unit operations (here only touched upon), are milling and furnaces. Typical examples of fundamental research relevant for appropriate production systems: the use of multicultures in, and the effect of, a not-constant temperature in fermentation processes; the heat economy of furnaces and dryers as a function of scale and fuel;

396. The major chemicals produced as a by-product of salt production are bromine, magnesium and potassium chloride.
397. See for example sections 4.3.1 and 4.5.1 on the EAIRO and NRDC who have a long-standing experience. FAO (1973) lists the considerable amount of R & D institutes already involved in this area. Chemical products from wastes on which significant R & D has been carried out include: numerous fats, oils and waxes (see section 5.2.6 and 5.6.3); gelatine, glue, gums, and similar; numerous fermentation products (alcohol (see section 5.3.4); butanol; acetic, citric, lactic, oxalic, and tartaric acid); various drugs (see section 5.4) and insecticides (see section 5.2.2); starch and derivates; furfural; silica; charcoal and carbon black (see section 5.3.3 and 5.4.4); proteïns (algal, fungal, leaves, animal waste); paper (see section 5.6.2). And further the use for building materials and as a source of energy.

maximum pressures obtainable in presses by human or animal force as a function of (material of) construction.

5.1.4 Stages of development. This is to be interpreted in two different ways: First the stages of development in establishing a conventional chemical industry taking into account the complexity and scale of standard chemical production systems, as well as the way different chemical production systems are dependent on each other, Secondly the stages of development of an economy (i e the local market), asking for different groups of chemical products. These two stages do not necessarily coincide. For example, in an early stage of economic development, there will be a market for caustic soda. But production of caustic soda usually takes place on a large scale and produces also chlorine (by electrolysis of salt). Even if a feasible production system can be started, given the market for caustic soda, there is not normally a significant market for chlorine at that stage of development.

What, at a certain stage of development, are feasible production systems, depends of course, much on the available raw materials and the prevailing world market for the particular product. Based on the characteristics of chemical production systems the following stages might be distinguished:[398]

(a) In the first stage there are production systems for oils and fats; cosmetics and soaps; polishes, inks, candles and matches; paints, varnishes and lacquers; and pharmaceutical formulations.

(b) In the second stage the following products are added: fertilizers (perhaps including ammonia); pesticides; detergents, dyes, and explosives; plastics and man-made fibres.

(c) In the third stage all (-but the most complex and integrated-) production systems are used, including those for acids, alkalis, salts, chlorine and other industrial gases; metallurgical reagents and additives,petrochemicals and synthetic rubber; complex dyes and pharmaceuticals.

Of course, such a list is not derived from a "basic needs-strategy"

398. UNIDO (1969a). See also the classification in Giral (1974) who distinguishes "equipment", "product", "process", and "operation" technology - the four groups being different in accessability of know-how and adaptive potential.

or anything of that kind. It just takes the integrated chemical industry in the USA and Europe as given and splits it up, according to internal criteria. A philosophy as outlined in section 5.1.1, would start from the list of chemical products imported in a particular country or region. (An example of typical imports is given in table 12). It is then checked what needs these products fulfil and analyzed to what extent these needs can be considered basic, and what alternatives there are to fulfil these needs. Such an analysis does not necessarily lead to the conclusion that certain production systems should be set up (either conventional or alternative) - it may well be that market structures have to be changed, or traditional production systems have to be modernised. Further, if the product is needed one should choose import substitution only if that is based on "indigenous technology". Investments should be in the latter and for the time being the chemicals needed should be imported.

If it is decided to make a particular product, by a foreign process this may coincide with decisions to do adaptive R & D. Major types of adaptive research are adaptations of a particular process to local resources or other particular boundary conditions (cf section 3.3). In the next subsection a few remarks are made on the problem of de-scaling. Economic de-scaling is often hampered by the non-availability of small-scale apparatuses.[399] As several examples given in this chapter will illustrate the new development of appropriate small apparatuses is not an easy matter.

5.1.5 De-scaling chemical plants. As has been stated in section 1.4 interest in de-scaling is negligible. At the world conference on chemical engineering in 1965 there were a number of contributions on the problems involved in establishing relatively small-scale plants.[400]

399. Significant LDC-producers of machinery are India and Brazil. See also section 4.5.1.
400. In particular from Bookout, Craig and Dubois, and Robertson. 'Todo lo expuesto nos permite concluir diciendo que es possible la planificación existosa de las operaciones de plantas de capacidad mínima, pero para ello es necessario conocer perfectamente todos los aspectos de la vinculacíonexistente entra la planta considerada y los elementos externos que hacen a la economía del pais. El ingeniero químico a quien generalmente le corresponde realizar la evaluación de la planta, debe tener presente todos estos hechos y profundizar su conocimiento en la medida que sea posible.' (Craig and Dubois, 1965).

TABLE 12 The chemical industry as supporting industry

important activities using chemicals	typical imports in LDCs to support these activities
agriculture	fertilizers, pesticides
health	pharmaceuticals, desinfectants
shelter	cement, titanium oxide
clothing (textiles, leather)	tanning and colouring agents, alkalis, blenches
mining and metallurgy	explosives, flotation and leaching agents
transport	fuel, components for batteries
consumption goods	paper, plastics, enamels, glass, detergents
chemical industry	sulphuric acid, caustic soda, soda ash
all	fuel

Although I assume that to some extent the large chemical concerns occasionally deal with a de-scaling problem, I know of no publications on this subject. Certainly, there has been no large-scale R & D project on this subject. Giral, working at the university of Mexico, has been for a long time involved in the economies and technical feasibility of de-scaling chemical production systems, but he does not seem to have had much succes in stimulating more activities in this field. Empirical findings and common sense regarding de-scaling can be summarized as follows:[401]

(a) Physical state of materials: Processes handling gases are more difficult to scale down than those handling liquids and/or solid. More phases or changes of phases give more problems in downscaling.

(b) Those continuous processes that cannot be easily broken down into batch operations are very difficult to downscale, but the number of such processes is less than is usually assumed.

(c) Often the major part of the investment costs goes to the separation operations, hence, this is where there is a potential to save on economies of de-scale, keeping in mind of course that here is a trade-off between simplification of the separation operations and recovery yields.

(d) Although the reactor is seldom a significant part of the investment, changes in reactor conditions influence all subsequent operations. This is often forgotten in transferring production systems to different boundary conditions.

(e) Small changes in product specification may have enormous effects

401. Following Giral (1972) and Robertson (1965). See also Chemical Engineering, January 3, 1966, pp 26-27.

on the apparatuses needed to carry out the operations needed.

(f) Apart from the question what is commercially available, there is a minimum size for each type of process equipment below which construction and maintenance become impractical. Of course, much depends on what *is* considered impractical work. More important is that one can usually find suitable substitutes. For example, below a certain scale tray-type distillation columns have to be replaced by packed columns.

(g) 'Plugging of lines, orifices and valves with dirt or in-process solids is potentially a bigger problem in small equipment than in large. Similarly, product losses (e.g., leaks and spills) can be very significant economically when production rates are small. And, in many cases, it is not economical to recover valuable material from the waste streams of small plants.'

(h) 'Small equipment has a greater surface-to-volume ratio than does big, and this difference can affect several things such as pressure drop', extractor and distillation efficiency. Temperature control is more difficult.

(i) Scaling-down becomes difficult when chemical and dynamic resistance are both rate-controlling. Vessels often must be specially designed to permit the proper condition of liquid residence time, level control, and gas handling ability.

(j) When well designed, small systems may be easier to operate due to their faster response. Also layouts and configurations can be used which would be impractical on a larger scale.

(k) Economies of scale for different apparatuses should be analysed in detail. For example, usually the economies of scale are larger for filtration/centrifuging than for drying.

5.2 Agriculture and food processing

5.2.1 Fertilizers. Plants need, inter alia, nitrogen (N), phosphate (P). and potassium (K). "Fertilizers" usually refers to natural or artificial products containing these three chemicals, and which are added to the soil. 'Numerous studies are conducted to test the yield response of fertilizers in the LDCs. ... These studies mostly confirm the positive relationship between fertilizer use and crop response though the degree of response does vary between the crops and between the types of fertilizer.' It seems however certain that optimum rates (in particular for N) are much higher for high-yielding varieties than for native varieties.[402]

The need for fertilizer can be fulfilled by using organic wastes or chemicals.[403] The use of organic wastes can be subdivided into the direct application of crop matter or animal manure, the application of composted organic waste,[404] and the use of anaerobically fermented organic matter. The latter possibility will be discussed in section 5.3.4 under "energy". The prospect of organic wastes should not be exaggerated, in particular not for high yielding varieties of grain, because they require nutrients in precise combinations. Secondly, the fertilizer value of organic wastes should always be compared with that of its other possible uses, in particular as fuel. Nevertheless, R & D on the use of organic matter as fertilizer, in particular for tropical regions, has been very limited, and is therefore a neccessary part of R & D programmes on the appropriate processing of agricultural waste. A positive reason to promote the use of organic wastes is that farmers in LDCs often lack purchasing power to obtain chemical fertilizers.

The major routes to chemical fertilizers are: (a) natural gas or naphta - ammonia - ammonia salts (sulphate, nitrate, phosphate, urea); (b) phosphate rock - phosphoric acid - phosphates; and (c) potash reserves - potassium chloride.[405] The latter is the least important fertilizer and asks for very advanced engineering and operation. For many tropical soils and crops, it does not seem necessary; if it is a po-

402. Eadie et al (1976, p.24), on which this subsection is heavily based.
403. A detailed analysis of the need for fertilizers should of course consider the whole eco-system of producing food.
404. I have not been able to find a recent survey on the state of the art in composting. There are many more failures than succesful projects. Typically the problem is that one 'has some difficulty in finding outlets for its products' (Marchés Tropicaux, 1975, on Humuci-Abidjan).
405. Transport facilities for such chemicals as phosphoric acid have become available rather recently. Together with the increase of transport costs in general, it is therefore to be expected that more and more complex fertilizers will be made. For example, producing nitric acid from ammonia and using this to decompose phosphate rock. Or, producing phosphoric acid to react with ammonia.

tassium salt is best imported.[406] All fertilizer production takes place in large-scale production systems using advanced technology. After a recent break-through the production of ammonia using centrifugal compressors has become particularly sensitive to economies of scale.[407] When making the choice of producing fertilizers three different stages can be distinguished:

(a) to import concentrated fertilizers and do the mixing formulation, and packaging locally;

(b) to import basic chemicals, such as ammonia[408] or phosphate acid, and process further;

(c) to start from raw materials, imported or from local resources.[409]

Predictions on future production and demand for chemical fertilizer very continuously as do prices.[410] The share of LDCs in both production and consumption of fertilizer grows, but very slowly. Prices vary also and are difficult to asses precisely - partly because much aid to LDCs is tied to fertilizer imports.[411] It seems certain that LDC-farmers pay on average much more for the same fertilizer than farmers in the USA and Europe.

Although economies of scale seem to be straightforward for fertilizer production, ironically,'despite a great demand for fertilizers in

406. Medium-scale, not too advanced production of K-fertilizer is perhaps possible as a by product from large marine salt works. NRDC-India has licenced a process producing 3000 tons of potassium schoenite per annum.
407. The old process using reciprocating compressors operates at a scale of 200-400 tons/day. The new process at 600-1500 tons/day. As far as such figures mean anything it is said that costs go down by one third over the range from 200 to 1000 tons/day.
408. As carbon dioxide is usually available in large-quantities on the place where ammonia is produced, import of urea may be more appropriate.
409. A large, but decreasing, amount of the phosphate rock is not processed at the place where it is found. The most common process to produce phosphoric acid was sulphuric acid. If cheap electric power, nitric acid, or hydrochloric acid are available other processes are possible. The last process seems to be the least sensitive to economies of scale. As remarked in section 5.1.4. all acids are "third stage" products.
410. World consumption of plant nutrients is expected to double in the period 1970-1980. Due to rising oil prices and constrained supplies of rockphosphates most authorities expect at the moment a shortage in the near future. In the last five years various ammonia factories were forced to shut-down. See om changing opinions the news items in eg *European Chemical News* and *Chemical Engineering News*. Research on a coal-based fertilizer industry is increasing.
411. For example India-USA and France-Ivory Coast.

LDCs, fertilizer plants operate at only 50 to 60% of total capacity.'[412] Reasons for this paradoxical situation include: lack of raw materials, lack of demand (no incentive on the part of the farmer for whatever reason), inadequate transport and storage facilities, inadequate maintenance and management.[413] Most of these factors would seen to be more manageable on a smaller scale.

Another factor which hampers appropriate fertilizer production in LDCs is the loss resulting from lack of bargaining power (see section 2.4.3). Even the recent old look UNIDO 'Consultation Meeting recognized that there were occasions when fertilizer plants and specific items of equipment had not functioned adequately, and buyers had suffered high consequential losses.'[414]

Due to the integrated nature of fertilizer production systems, both technically and financially, it is next to impossible to assess the consequences of the choice of scale in fertilizer production.[415] There is

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412. Eadie et al (1976, p.111). Also: 'The Meeting noted that the current situation in several developing countries was not satisfactory; the efficiency levels and the capacity utilization were below desired levels. The Meeting recognized that the effect of making fuller use of capacity in existing plants would be equivalent to that of setting up several new fertilizer plants.' (UNIDO, 1977a).
413. UNIDO (1977a) gives as major reasons for low operational efficiencies and capacity utilization problems arising from faults in plant design, inadequate infrastructure, faulty maintenance and market contraints.
414. UNIDO (1977a). Particular cases are always complex: 'In 1970, FCI (Fertilizer Corporation of India) was succesful in having the American company Chemico excluded from the list of possible contractors for expansion of the Trombay fertilizer plant. The United States Agency for International Development (AID) had previously stipulated that no funds would be allocated to the project unless Chemico was considered as a potential contractor. FCI's reluctance was due to the reported failure of an existing ammonia plant, constructed by Chemico, to reach rated productive capacity for the first two years of its operation. FCI claimed that this was the result of faulty design, whereas Chemico maintained that the fault lay with another US company, unnamed in the report, who were responsible for the design of nitrophosphate and methanol facilities, and with the FCI itself for poor management.' (Eadie et al, 1976, p.77).
415. 'It had been hoped to produce evidence of returns on foreign assets held by technology supplying assets. No such evidence is avalilable.... To the best of our knowledge no analysis of patent ownership in fertilizer production processes has ever been carried out on a systematic basis. ... Separate statistics of financial performance in fertilizer technology supply are not available.' (Eadie et al, 1976, pp.57,58,62).

scope for a detailed study on this matter as well as R & D directed to improving the efficiency of small- and medium-scale production systems. As the bias is usually to large-scale, I summarize here the major factors that may favour medium-scale decentralised production:

(a) Plants with a capacity of 50-250 tons/day using conventional processes (for urea or phosphate can be produced on a "package" basis.[416] Because they are smaller and more or less pre-fabricated, such a plant can start production after 12-18 months, in stead of 3-5 years for large plants. This difference effects (i) interest charge en investment, (ii) costs of imported fertilizer or foodgrain, (iii) psychological factors related to time-span of reaching (national) goals.

(b) The small-scale plant produces for a smaller area.[417] Hence transportation problems and the complexity of the sales organisation is simpler. This may not only affect "ideal" costs, but even more so costs in practice due to non-ideal operation. (Cf the prevailing over-capacity mentioned above.)

(c) Managerial and technical problems are simpler. Hence, although the plant itself has to be bought, the chances of having an indigeneously owned and operated production system is much larger.

(d) It may be possible for the more advanced larger LDCs to buy a few plants and later be able to construct and build most of the components of these conventional plants, themselves. If, however, the most

416. The prospects of ammonia and urea 'packaged' plants in this scale range have been much discussed in the sixties. See, e.g., UNIDO (1964), Foster and Wood (1968), Erlenkotter and Manne (1968). From 1969 onwards the influence of the break-through in ammonia production became dominant (illustrated for example by the withdrawel of the multinational oil companies from the market). I have not been able to find any recent detailed study of cost comparison for the conventional and the new process, making a clear distinction between economies of scale for capital investment and energy consumption.

417. If the factories are situated in-land, this has the advantage of industrial dispersion and shorter transport distances for ready fertilizer (because, when situated at the coast the surroundings are partly sea). However, raw materials have to be transported to the factories, which may burden the infrastructure.

418. I pass over the developments in biological and integrated pest control and I assume that the need for chemical pesticides is, at least in some areas, a basic need.

419. The synthetic insecticides include the chlorinated hydrocarbons (DDT, BHC, aldrin, dieldrin,...), the organophosphates, and the carbamates.

recent innovations are followed, dependency will remain a problem for a very long time.

5.2.2 Insecticides.[418] The production of most synthetic insecticides[419] is not particularly difficult, but the raw materials (petrochemicals, chlorine, ...) are the output of advanced integrated chemical industries. Unless the production of insecticides is combined with other chemicals, there does not seem to be a case for import substitution by importing the raw materials for artificial insecticides.[420]

There are a few natural insecticides, mainly hydrocarbons (from petroleum) and the plant extracts pyrethrum, rotenone, and nicotine.[421] In the literature on appropriate production systems the plant extracts are often mentioned as a potential source of development. It should however be noted that the world market for these products is limited, whereas these insecticides are not necessarily the ones needed in the areas where they can be produced. Bearing this in mind, it is however worthwile to investigate in which areas of potential production they could fulfil a need, as well as improving the small-scale production systems to obtain the extracts. The first stages of production should naturally be carried out on a small-scale, because, as with most plant extractions, quality and efficiency are higher if processing is begun immediately after harvesting.

5.2.3 Post-harvest drying. 'The post-harvest end of plant and animal resource development has tended all too often to get less than its due share of attention ...'[422] Because agricultural products in general deteriorate very quickly after harvesting, too slow or inappropriate

420. Processing the concentrated insecticides together with a carrier (clay, talc, diatom earth, etc.) into a powder or granular form for use, seems appropriate. Because of the nature of the chemicals the unit operations in this production system (such as mixing, pelleting, drying) do not lend themselves for labour-intensive or family scale production.

421. Pyrethrum is obtained from flowers which have to be dried, powdered, and then extracted (usually with petroleum ether). Major producers are Japan and Kenya. Rotenone is obtained from the roots of *Derries* species. Nicotine is obtained as sulphate from tobacco waste, most commonly by steam distillation from an alkaline solution. All of them break down quickly under the influence of light, a disadvantage which is often overlooked in new look suggestions.

422. Spensley (1974), who estimates that the value obtained by LDCs in the post-harvest sector, is 35% of the final value of the commodity and could become 70%.

processing leads to great losses - 60% being no exception. These problems have been exacerbated with the introduction of high yielding varieties. The major post-harvest unit operations are: milling or cutting, drying and other heat treatments, oil extraction, storage and transport. Here I briefly discuss some aspects of drying granular agricultural products.

The main advantage and sometimes necessity of small-scale drying is the deterioration, during transport to large-scale dryers. Most small-scale operations have the disadvantage of a non-uniform product treatment (andhence quality), and a low energetic efficiency[423] (although , in the case of sun drying this is not paid for). Knowledge of drying of tropical agricultural products and in particular the technology of them is limited. In a survey we made for a number of granular products, we hardly found any performance data of small-scale dryers, and not one systematic comparison of different dryer types for the same product, giving at least investment costs, heat economy, and product quality.[424]

Recently, the interest in the optimal design of solar dryers has increased considerably, but for the rest virtually no R & D is carried out on small-scale dryer designs. The following may serve as an example of the lack of interest in this subject. A so-called "spouting-bed" dryer has a number of potential advantages as a small- and medium-scale

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423. Energetic efficiency of drying ranges from 5% for simple sun drying, 15-40% for simple artificial dryers, to 40-65% for sophisticated dryers; major factors increasing efficiency are: appropriate air flow, recirculation, mixing, heat insulation.

424. Selected Bibliography on small-scale dryers for granular agricultural products. *General:* 1. A Survey of Solar Agricultural Dryers, Quebec: Brace (1975); 2. H. Pelgröm. Het Drogen van Tropische Land- en Tuinbouwproducten, Amsterdam: KIT (1975); 3. C. Agr. Prod. Pays Chauds, 22 (10) (1967) 227; 4. Sulzmayer, Food Technol. Austral., 23 (1971) 440; 5. Manuel de Conservation des Produits Agricoles Tropicaux, Paris: CEEMAT (1971); 6. Tropical crop processing, drying and storage equipment, World Crops, Sept./Oct. 1975. *Rice:* 7. A. Angladetta, Rice Drying: Principles and Techniques, Informal Working Bulletin No. 23, Rome: FAO (1966); 8. Rice: Chemistry and Technology (D.F. Houston, Ed.), Am.Assoc.Cereal Chemists, Minnesota (1972), Ch. 5; 9. A.U. Khan, Trans ASEA, 16 (1973) 1131; 10. IRAT, C.Agr.Pr.Pays Chauds, 22 (10) (1967) 187-193. 11. A.S. Manalo, Rice hulls as fuel for drying paddy, IRRI, Saturday Seminar, Sept. 11, 1971; 12. J.R. Arboleda, Accelerated conduction drying of paddy, Ann. Convention Philippine Society of Agricultural Engineers, Manila (1973); 13. Cereal Technology (S.A. Matz Ed.), AVI Publ.Co., Westport (Conn.), 1970; 14. Portable Food Grain Drier, Delhi: NRDC; 15. W.J. Chancellor, Mal. Agr. J. 45 (1) (1965)65,Trans. ASAE, 11 (1968) 857, 863; 14 (1971) 536; 16. Agric. Mechaniz. in Asia, Autumn 1973; 17. Agricultural Mechanization in Developing Countries (M.L. Esmay and C.W. Hall, Eds), Tokyo: Shin-Norinsha ch.6; 18. M.K. Bhashyam et al, J. Food Sci. Technol., 14 (3) (1975) 124; 19. P.H. Bailey and W.F. Williamson, J. Agr. Eng. Res., 10 (3) (1965) 191. *Peanuts:* 20. B.N. Ghosh, Proc. Int.Symp. Tropical Root Crops, vol.2, Trinidad (1967); 21. Peaunuts: Production, Processing, Products (J.G. Woodroof, Ed.), AVI Publ.Co. Westport (Conn.), 1973. 22. S.M. Blatchford en D.W. Hall, Tropical Sci., 5 (1963) 6-33, 82-98. 23. J. McCloy, Some results on the artificial drying of groundnuts, Tanganyika Agricultural Corporation. 24. E.E. Gay. G.L. Nelson en B.L. Clary, Trans ASAE, (1973) 104-108. 25. B.L. Clary, K.K. Agrawal en G.L. Nelson. Simultaneous heat and mass transfer from peanuts in a spouted bed, 1970 Winter Meeting ASAE. *Cocoa beans:* 26. B.N. Ghosh, World Crops, 25 (5) (1973) 232-237; 27. D.H. Urquhart, Cocoa, Longmans, London (1955), ch. III; 28. G.R. Howat, B.D. Powell , G.A.R. Wood, Tropical Agricultural (Trinidad), 34 (1957) 249; 29. G.A.R. Wood, The Planter, 47 (1971) 449; 30. D.W.M. Haynes, Malayan Agric.J., 41 (2) (1958) 88; 31. J.A. Anselmi, Liu Shing Nam en Mu Chun Hain, The Planter, 50 (1974) 144; 32. G.A.R. Wood, Tropical Agriculture (Trin.), 38 (1) (1961) 1; 33. M. Richard, Café Cacao Thé, 13 (1969) 57; 34. J.C. Vincent, Café Cacao Thé, 12 (1968) 343. *Coffee:* M. Sivets en H.E. Foote, Coffee Processing Technology, AVI Publ. Co., Westport (Conn.), 1963, ch. 4 en 5. 36. Manual del Cafetero Colombano, Federacion Nacional de Cafetero de Colombia, 3e druk, Bedout, Bogota (1969). 37. A.L. Philips, Solar Energy, 9 (1965) 213-216. 38. G.R. Henderson. Kenya Coffee, 24 (278) (1959) 49-51. 39. J.F. McLoy, Kenya Coffee, 24 (280) (1959) 117-133. 40. A.E. Wootton, F.A. Verkade , W.H. Mitchell, Tanganyika Coffee News, 9 (1), (1968) 13-25.

dryer. It is rather insensitive to economies of scale and if compared with dryers of a similar degree of technical sophistication, it gives a much more uniform product treatment, the drying is much shorter, and other heat treatments can be applied in the same reactor.[425] During the sixties large-scale spouting bed dryers came into use in the USA for drying wheat and peanuts. However, today, those institutes involved in post-harvest technology in tropical regions, usually do not even know what a spouting bed is.[426]

5.2.4 Cassave processing. In the previous subsection we considered one important unit operation in post-harvest technology. Here we consider one typical example of food processing of a single product. The cassave plant is also known as manioc, yuca, and tapioca. It is a typical example of a crop that has a variety of potential uses. For the cassave root or tuber these are:

(a) as a staple source of carbohydrate where it is grown, either consumed directly (i e after peeling and boiling), after some processing (to products such as gari or farinha), or as a flour substitute in bread;

(b) as a source for the animal feed industry (mainly used in the EEC as a source of energy (carbohydrates) in animal feed);

(c) as the raw material for producing starch (used mainly in the food industry as a binder or as a source for glucose, and in the textile industry).

R & D on the use of cassave as a cash crop and input for indigenous export industries is developing well.[427] As an example of the scope for improvement in the processing of staple crops I shall discuss here the manufacture of gari. Gari is prepared in West Africa from cassave by peeling and grating the roots. The grated root is fermented under pressure for 24-48 hours, and then sieved and fried. At present there are three levels of production:[428]

(i) Traditionally gari was made on the family level with dangerous

425. Presently a research project is carried out at this laboratory on the design and socio-economic feasibility of small-scale spouted bed dryers. We hope to report on the potential advantages of the spouted bed in the near future.

426. At the university of Nairobi research is carried out on the drying of pyrethrum in a spouted bed.

and highly inefficient grinding methods and fermentation in bags pressed down with stones. Innovation on this scale started about 20 years ago by the introduction of small motorized grinding machines on the village level. More recently attempts have been made to design cheap grinding machines using pedal power, but it is not known to what extent they are used.[429]

(ii) In the late 1950's research was started in Nigeria (at the FIIR) on the possibility of innovation in the processing of cassave. A mechanized small scale plant (10 tons a day) was developed and is now available under license of a British firm.[430] The first plant started operation in The Gambia in 1970. Operations had to be stopped in 1974 because of a number of problems: continuous supply of input could not be answered; the sophisticated equipment led to severe maintenance and servicing problems; although labour was abundantly available the three-shift basis operation caused unsurmountable social problems; the capital/labour and capital/output ratio appeared to be too high to produce economically.

(iii) As an off-shoot of the civil war in Nigeria at least two indigenous gari production systems have been developed.[431] They have an

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427. IDRC has established an international cassave research network (Nestel and Cook, 1976). See for a summary of the industrial manufacture of cassave products Edwards (1974), De Bruin et al (1973), and references given there. 'Developments in starch technology have mainly taken place in the industries of North America and Europe, and hence have been applied to the processing of products such as maize and potatoes.' (Edwards, 1974). Research priorities would seem to be (i) optimal hydrolysis conditions; (ii) economic use of water in arid regions; (iii) efficient drying. At TPI considerable research is carried out on the use of cassave and other tropical crops as bread substitutes. See on bread also Hall and Wurdemann (1975).
428. The information given under (ii) and (iii) is derived from Kaplinsky (1974a), Molenaar (1976) and various personal communications.IDS-Sussex and the University of Ife in Nigeria are carrying out a project on the impact of innovations in gari-production.
429. The price of the motorized machines is in the order of £ 200. At the "Zaria Intermediate Technology Workshop" (Nigeria) a pedal power grinder has been designed using local materials. It would cost in the order of £ 20. See ITDG-Bull. No 7, July 1971. It is also mentioned three years later in the second issue of the ITDG journal "Appropriate Technology" (Lee, 1974), but without indicating how many had been produced by then.
430. The Newell Dunford Company. The prototype as developed by the FIIR is said to be operating in Lagos.

output of about 3 tons a day and are made wholly from local materials. The capital-output ratio is estimated to be one third of the sophisticated production system described above. It should further be noted that they have been set up with almost no R & D costs.

Although the innovation in gari production - too briefly described above - is just one example, I think it is quite representative to obtain an idea of what problems there are, and what kind of activities are more relevant than others.

5.2.5 Leaf protein.[432] Many green leaves, grasses, and similar can be treated in rather simple ways to produce protein concentrates. Typically green leaves are first pulped to disintegrate the tissues, then the leaf juice is extracted from which the proteins can be coagulated. Machines for extracting protein have recently been developed in various industrialised countries, while research institutes all over the world are involved in R & D on this subject.[433]

5.2.6 Edible oils and fats. Natural fats for both food and non-food purposes have been used since the Egyptians. Apart from use in food, traditional applications include the use of fats as lubricants, in candles and lamps, in the production of soap, and as protective or decorative coatings. I restrict the discussion here to vegetable as distinctfrom animal oils and fats; a few of the principle sources are given in table 13. It can been seen that many edible oils have also other applications, nevertheless about 90% of the (vegetable and animal) oils and fats are used for edible products, For many industrial uses there are synthetic alternatives, e g petroleum waxes for candles.

Fats may be recovered from oil-bearing tissues by rendering, pressing, or solvent extraction. For most applications the extracted oil has to be further processed (refining, bleaching, winterizing, hydrogenation). These latter stages ask for much more sophisticated techniques

431. One by a firm called "Fabrication Egineering and Production Company", another by the Nigerian Eastern R & D Institute "PRODA" (a unit that seems to be operating on a more applied level than the central FIIR).
432. This subsection is included for reasons of completeness only. I have not studied this subject.
433. For example: Dept. Food Science, Univ. of Wisconsin; ICAITI (Inst. Centroamericano Invest. Technol.Indust.); Univ. of Ife (Nigeria); Swedish Sugar Corp.; Pakistan Council for Sci. & Ind.Res.

then the extraction itself, and are usually carried out in industrialised countries or by subsidiairies of multinationals.[434]

The extraction of the crude oil is carried out on any scale. If the crude oil is produced for the world market, quality is determined by standard specifications. Often, the best quality for the local food market is very different from the best quality for export. By using more sophisticated extraction equipment more oil can be expressed. Large-scale production systems, however, often find other restrictions for obtaining a high yield and quality. For example, in processing palm nuts, on the family level the shells are removed by hand and this rarely gives damaged kernels. On the other hand, a commercial mill applies mechanical decortication which gives a high proportion of bruised and damaged kernels. In particular, if the freshly-cracked nuts are not at once processed further the mechanical process has a serious effect on the quality of the oil obtained. In general the time between harvesting and extraction is crucial for product quality.[435]

On paper R & D activities concerned with oilseed growing and processing have always been considerable and are steadily increasing. For example, there is a complicated network of institutes and publications, - apart from the professional interests of the multinationals in this field - that deal solely with the oil palm.[436] As with many other

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434. Over the past five years or so the number of edible oil refineries and fractionation plants installed in LDCs, have increased considerably. Companies such as H.V.A.-Holland Agro Industries are slowly withdrawing their own production systems in LDCs and become contractors of, inter alia, small-scale food processing plants. They estimate that 'Investment in a small-scale vegetable oils processing plants including fractionating with a capacity of ca. 4,000 tons/annum can be justified if a market of 500,000-800,000 potential consumers is available.' (Kreulen, 1976). Such a plant would cost about US $2 million, of which 75% would be in foreign currency.
435. An extreme example of the influence of the input quality on the output quality, is that of rice bran. The world production of rice has a potential of producing as a by-product 2 million tons of rice bran oil per year. Although there exist commercial production units for rice bran oil (eg in Japan and Burma), and R & D on the subject was started in the fifties (see eg Beck, 1958), the problem of stabilizing the rice bran is still a major inhibitor to progress (UNIDO, 1976b).
436. TPI operates the "Oil Palm Advisory Bureau" which publishes "Oil Palm News" and there are specialized R & D institutes in Brazil, Indonesia, Nigeria, Ghana, etc.

TABLE 13 Principal vegetable oils and fats

type	principal sources	principal uses
linseed	N. America, India, Argentina	paint, varnish, ink
soybean	China, U.S., Manchuria	food, paint, resins, chemicals
corn (maize)	U.S., Europe, Argentina	food
sunflower	S. America, Eastern Europe	food, resins
cottonseed	U.S., India, Egypt, USSR	food, soap
peanut	India, West Africa, U.S.	food
olive	Meditterranean countries	food, soap, pharmacy, lubricants
castor bean	India, Brazil, Meditteranean	medicine, lubricant, chemicals
shea butter	West Africa, The Sudan	food, soap, candles
palm oil	West Africa, Indonesia, Brazil	soap, candles, food
cocoa butter	Indonesia, Malaysia, W. Africa	chocolate, pharmacy
coconut oil	India, Indonesia, S. America	food, soap, chemicals

post-harvest techniques the development is characterized by many unsuccesful attempts to establish modern medium- and large scale oil mills[437] and very little serious interest in improving the traditional small-scale extraction techniques.

The first aspect may be illustrated by the attempts to mechanize palm oil extraction in Nigeria. This programme was started in 1953 and again in 1962, and originally concentrated on medium-scale oil mills[438]. Around 1959-1965 a small-scale hydraulic handpress[439] was specially designed for use in West Africa as an alternative to the

437. Sri Lanka. 'An oils and fats mill was established in the public sector when the private oil-milling industry was already saddled with excess capacity. Hence the mill had to be operated at only one-third its capacity. Its fat-splitting, fatty acid distillation and glycerine concentration plants were never operated on account of the absence of markets for their products. In seeking to reduce losses (and to lower costs) the project agency mechanised the movement of raw materials and finished products within the provender plant by installing elevators and conveyors. This plant was originally designed to use labour for such operations' (Hewavitharana, 1971).

438. From 1953 onwards small oil mills were established. Although Howat (ref. 4 in note 440) states in 1975: 'In recent years there has been an increase in the number of palm oil plantations with fully mechanized oil mills as an integral part of the project. They do produce oil of a much better quality and many of them are well managed and profitable investments. The firm of Sork Gbr. Germany [sic!] usuallly supplies the equipment which is well-adapted to West-African conditions.', but I think the observationsof Reusse (1976, ref.5, cf also ref.3) are more according to the facts: 'Les huileries industrielles n'ont jamais traité qu'une petite partie de la production et ne sont pas florissantes en dépit de l'aide de l'Etat.'

fully mechanized hydraulic presses used in the oil mills. Nevertheless still more than 80% of the palm oil is produced on a family scale, while small- and medium-scale production systems are (in)directly subsidized,

The lack of interest in improving family scale extraction methods is clearly illustrated by a literature survey we made of small presses using human or animal force:[440] no performance data, comparitive tests, or tests reports on improved designs exist. Every press costing less than, say, US$ 3000, - is a priori dismissed because extraction efficiencies will be low. Although this may be true, it is slightly simplistic to assume that comparing the de facto efficiency of traditional production systems with the theoretical efficiency of modern production systems is the decisive criterion to be used.

5.2.7 Sweetening agents. The major sweetening agents are white crystal sugar, khandarsi and gur (non-white sugar cane products), and glucose ("corn-syrup"). World consumption consists for about 80% of white sugar, 12% of khandarsi and gur (mainly in India, Pakistan, and Sri Lanka), and 8% glucose and other sweetening agents. Except for khandarsi and gur the production of all sweetening agents is of a rather recent origin. Gur has been produced on a village scale for milennia; it consists mainly of non-refined sugar and molasses obtained from sugar cane

439. The hydraulic handpress was designed in 1959 by Gebr. Stork & Co's Apparatenfabriek, Amsterdam (The Netherlands). 'Owing to the very much higher pressures obtained in this press compared with the screw hand press widely used in West-Africa, the extraction rate may be as much as 40 per cent higher...'writes Cornelius in 1963 (ref.1 in note 440) and Nwanze (ref.2) concludes in 1965: 'From these figures it is evident that even at low returns to the producer (i.e. less than half the world market price) the pay-off time for the handpress is less than one year and the profit accruing from the kernels makes the project economically profitable.' But in 1975 their contribution to the national output of palm oil was still negligible (Zeven, ref. 3).

440. Selected bibliography small-scale extraction presses (compiled by C.J. Risselada): 1. J.A. Cornelius, Tropical Sci., 5(1963)34; 2. S.C. Nwanze, J. Nigerian Inst. Oil Palm Res., 4(1965)290; 3. A.C. Zeven, The Semi-Wild Palm Oil and Its Industry in Africa. Thesis, Wageningen (1976); 4. G.R. Howat, Developments in the edible oils and fats industry in West Africa, Seminar on Food Science in West Africa, Univ. of Ghana (1975); 5. E. Reusse, Bull.Econ.Stat.Agric (FAO), Sept./Oct 1976. 6. H. Camps-Fabrer, L'Olivier et l'Huile dans l'Afrique Romaine, Alger (1953); 7. H. Blümner, Die Gewerbige Tätigkeit der Völker des klassisches Altertums, Leipzig (1869). 8. J.S. Da Silva, Trop.Agric.48 (5)(1917)303; 9. Olive oil Processing in Rural Mills, FAO (1956) 10. A.M.W. Geddes, Appr.Technol. 3 (2) (1976)6; 11. G. Hefter, Technologie der Fette und Oele, Berlin (1906); 12. Hermbstädt Bulletin der Neuesten und wissenwürdigsten aus der Naturwissenschaft, Berlin, (14) (1813) 102; 13. F.W.T. Hunger, De Oliepalm, Leiden (1917); 14. R.M. Johnson and W.D. Raymond, Colonial plant and animal products, 4 (1954)14; 15. H.P. Kaufmann, Neuzeitliche Technologie der Fette und Fetter Produkte, Munster (1961). 16 J.H. Kimman, Een historisch overzicht over de kennis der oliën en vetten en de ontwikkeling harer industrie, Oliën en Vetten 1917, 1918 (various issues); 17. G. Borneman, Die Fette und Oele des Pflanzen und Tierreiches, Weimar (1889-91); 18. M. Rühlmann, Algemeine Maschinenlehre, Band II, Braunschweig (1865); 19. British vegetable oil industry, The Cotton Oil Press, 4(11)(1921)40; 20. W.R. Tromp de Haas, Teysmannia, 15 (1904)674. 21. L. Ubbelohde, Chemie und Technologie der fette und Oele, Band I, Leipzig (1908); 22. A.P. Usher, History of Mechanical Inventions, Harvard University Press (1954); 23. UNIDO Expert group meeting on pre-investment considerations and technical aid and economic production criteria in the oilseed processing industry, Vienna (1972). 24. Reports subcommissie microprojecten, Eindhoven University of Technology (1973, 1975); 25. J.J. Hetzler, Het Winnen van Oliën uit Oliezaden met Aangepaste Technologiën, Amsterdam: KIT (1976); 26. H.P. Kreulen, J. Am .Oil Chemists Soc., 53(1976)393; 27. P. Goyle, Cottage Industries Guide, Calcutta: Bico.

by simple techniques for extraction of the juice (by crushing), boiling and clarification. Khandarsi is non-refined sugar produced on a small-scale by a variety of techniques, mainly distinguished from modern sugar mills by the fact that they do not use vacuum distillation.

The discussion on appropriate production systems for sugar, mainly centres around the appropriate scale of modern sugar mills (balancing economies of scale against transport problems for raw materials and product) and the feasibility of improved techniques for small-scale khandarsi production (in particular by the so-called "open pan sulphitation process") as an alternative for medium- or large-scale production in mills. As I intend to write a detailed critical review on this matter, here I only list the major problems involved in evaluating the choice of production system:[441, 442]

(a) Based on conventional criteria most analyses conclude that the only feasible production system is large-scale and capital-intensive. But there are the usual problems of how to evaluate in a given context

441. The largest research project on the choice or production systems for sugar is presently being carried out at the Livingstone Institute (Glasgow, see section 4.3.4). There seems, however, to be some problem in interpreting the results. In an article in "World Development" in 1974 Pickett, Forsyth, and Mc Bain (ref. 7 in note 442) write among other things: 'From the table it can be seen that the open-pan process would have been superior to the vacuum-pan process on each of the four criteria listed.... The open-pan process would not only have been more profitable than the Ghanaian factory. It would also have used less capital and provided more employment'. This article and this conclusion is neither referred to in the many papers by Picket and other members of the institute at the 1977 Nairobi Sugar Seminar, (ref. 16 in note 442), nor in a publication by Forsyth in 1977 (ref. 15) in the same journal, where he concludes that 'Contrary to recent suggestions in the literature [i.e. those by Garg and Baron, refs. 10 and 12] , capital-intensive technology is shown to be clearly superior at all but the smallest level of scale, and unit costs are found to fall sharply as output rises.' Furthermore, this 1977 paper of Forsyth is not referred to in any of the papers at the 1977 Nairobi-seminar.

442. Short bibiography on small-scale sugar production: 1. Roy, S.C., The Gur Monograph, Indian Central Sugarcane Committee (1951); 2. Goyle, P., Cottage Industrie Guide, Calcutta: Bico; 3. PRAI Publications Nos. 226, 260 and 350 on Open Pan Sugar Manufacture (1965, 1968, 1969); 4. Report of the Sugar Enquiry Commission, Delhi: Govt. of India (1965); 5. Hewavitharana, B., in: Econ. Dev. in South East Asia (E.A.G. Robinson & M. Kidron, Eds.), London: Macmillan (1970, pp. 431-452); 6. Van der Wel, P.P., I.S.S. Occasional Paper No. 26, The Hague: Institute of Social Studies (1973); 7. Pickett, J..et al, World Development, 2 (3) (1974) 47-54; 8. Techno-Economic Feasibility Rept. on Mini-Plants in Pakistan, London: ITDG (1974, pp. 73-140); 9. Bodewes, H., Kleinschalige Suikerproductie in Ontwikkelingslanden, Delft University of Technology, lab. chem. werktuigen (1975); 10. Garg, M.K., Working Paper Study Group on Low-Cost Technology and Rural Industrialization, Paris: OECD (1974); 11. Pyle, L., Choice of Technology in Sugar Manufacture, mimeo, London: Imperial College (1975; revised and extended version soon to be published by (ITDG) ; 12. Baron, C.G., in: Technology and Employment in Industry (A.S. Bhalla, Ed.), Geneve: ILO (1975, pp. 175-200); 13. Study of the Operation of Gur (Gula Djawa) and Khandarsi Sugar Plants, Amsterdam: HVA Internationaal (1975); 14. Small-Scale Sugar Production in Kenya, 3 vols., Nairobi: Agroinvest(1976); 15. Forsyth, D.J.C., World Development, 5 (3) (1977) 189-202; 16. Final Report of the Joint UNEP/UNIDO Seminar on the Implication of Technology Choice in the African Sugar Industry, Nairobi, April 1977, ID/WG.247/22, and papers presented there by Behari, Alpine and Duguid, Mac Gillivray and Moore, Patureau, Barclay, Ohingo, Almazán del Olmo, and Pickett.

factors such as impact on domestic engineering and the R & D sector; the social costs of foreign currency and iron and steel; decentralization of economic power and balanced growth; labour intensity, concentration of labour, and use of skilled labour and entrepreneurship; etcetera.

(b) There are large discrepancies between potential and actual efficiency of operation and economic benefits at all scales. It is not exceptional that large-scale factories work at 10% of their planned capacity[443] and gur-producers typically extract 60% of the sucrose which they ideally could obtain with the type of production techniques they use.

(c) Reliable technical or economic data on actual performance of the less conventional production systems are not available.[444]

(d) The outcome of social-cost benefit analyses depends strongly on (i) the days of operation per year (and, hence, is related to the techniques of cane growing), (ii) the prices of input and output (which may be different for different production systems, due to state intervention), (iii) different tax structures for different scales of operation.

(e) In comparing crystal sugar, khandarsi, and gur, three different products are compared. Prices and accessible markets depend on the requirements or tastes of the buyers. For example, the nutritional value of gur is much higher than of refined crystal sugar, but it is hygroscopic and most people prefer the appearance of white sugar. The possibility of producing gur or khandarsi as input for large-scale refineries has to be considered.

(f) On first view the efficiency of large-scale operations is much better: they obtain more sucrose from the cane and use less energy. But there are a number of factors which provide alternative evaluations, in particular: transport costs for input and output; influence of har-

443. For example in Sri-Lanka (ref.5 in note 442) and Ghana (ref.6).
444. Typically, it is reported in 1965 in India there are 114 so called OPS-khandarsi-units in operation (ref.4 in note 442), while in 1977 'more than 7,000 khandarsi units are reported to be operating in different parts of the country at different levels of technologies and their details are not yet available.' (Behari, ref. 16).

vesting and processing on yields; processing of waste water and the by-products molassis, bagasse, and ashes.

5.2.8 Alcoholic beverages. The small-scale production of alcoholic beverages from local agricultural products is an age-old tradition: palmwine, pulque (from agave), rum (from sugar cane byproducts), beer (from maize or millet), gin (from sugar or palmwine), etcetera. Nowadays family and small-scale production is usually illegal because of health hazards. These are in many cases quite serious. It is however doubtful whether police raids are a better investment than attempts to improve the quality of family scale production by instruction and perhaps temporarily subsidize these marginal production systems.[445] There has always been interest in, of course, the large-scale production of export products, and more recently in import substitution (in particular for the raw materials used in large-scale beer production[446]). But I know of not one piece of significant R & D in, for example, the performance and possibilities of improvement of small-scale distillation apparatus for the production of alcohol.[447]

445. Consider the following evaluation of the illegal brewing of 'buzaa' (a kind of beer) by women in the Mathare Valley in Nairobi: 'for many women with few skills marketable in the formal sector, no husbands and no land, this self employment in brewing buzaa is a simple and practical means of subsistence. ...By participating in this 'crime without victim' it can be said without exaggeration, that most of these women avoid being a drain on Kenya's resources; and many contribute to her progress either indirectly through educating their children or directly by sending money to the rural areas or by building houses.' (Nelson, 1973)
446. At the DLI a 'choice of techniques' study is carried out with respect to large scale beer production (Keddie and Cleghorn, 1975).
447. The FIIR designed a small-scale destillation unit for the production of spirits from palm wine (Akinrele, 1974), but no exact design and performance data are available. Although the existence of the numerous stills in use all over the world is often mentioned, we have as yet not been able to find any detailed description, let alone performance data. (See for references on the history of (rural) alcohol production: Merrill and Aston (1975).) It seems that there is little scope for improvement of traditional methods in the given context, because any improvement in "technical" quality will make the product more expensive on a market that is used to the "low-quality" taste (various personal communications in Nigeria and Kenya). Nevertheless I think it could be intersting to do sophisticated measurements on traditional systems and to investigate whether or not improvements in design and operation are possible that do not increase costs.

5.3 Energy

5.3.1 Sources of energy. Within the range of chemical production systems comes the use of fossil and renewable fuels containing carbon. I shall not discuss the fossil fuels[448] and I shall only make a few remarks on processing fuel from agricultural and forestry resources. These resources can be classified into: wood (waste), waste of cereal crops, fibres (seed hair, bast fibre, leaf fibre), sugar cane waste, waste of vegetable and fruit crops, manure. Further, the major processes used to obtain an appropriate fuel are as follows: (a) hydrogasification, (b) hydrogenation, (c) pyrolis or destructive distillation, (d) acid hydrolysis, (e) anaerobic digestion, (f) alcohol fermentation, (g) charcoal making, (h) direct burning. The list is roughly in the order of the complexity of the processes.[449] In all cases the processing to fuel has to be compared with alternative uses of the raw material. In this section I shall only briefly discuss (e) - (g).[450]

5.3.2 Charcoal.[451] Primitive methods of charcoalmaking exist in many LDCs - although often wood is used as fuel where charcoal might be better (because not everybody can make charcoal, and hence one has to pay for it). Assuming that there is no reason to decrease the use of wood, there seem to be considerable possibilities of improving family-charcoal making techniques, and to introduce small-scale charcoal producing units that use a simple kiln.

448. See on wood and coal note 395. As most OPEC-countries are building or intend to build large oil refineries, there seems to be in general little scope for import substitution refineries in LDCs. This policy has not been very successful in the past, and in the present situation there is even more reason to concentrate on other investments. (The situation is more complex in the case of nitrogen fertilizer for which OPEC-countries also have vast plans.)
449. See NAS (1976) for a review of "energy for rural development".
450. The pyrolisis and gasification process is also seriously considered in industrialized countries to treat wastes. Twente University of Techno-gy (The Netherlands) is involved in various cooperation projects assessing the potentialities of small gasification units in rural areas.
451. See Dryburgh (1974) for "Suggested improvements to charcoal making and an assessment of their limits of applicability at different levels of operation." A medium-scale unit producing charcoal briquettes (using 80-100 tonnes of input per month) is already a sophisticated industry for which machinery has to be bought in Japan or USA - at least, that is the view of the regional adviser for small-scale industries of the Economic Commission for Africa (Noury, 1976).

In the literature on "appropriate technology" one often finds a lot of enthusiasm for wood destillation, but on a family scale there are no possibilities at all, for obtaining by-products; while on a small- or medium-scale the only viable byproduct is coal-tar. If there is any future for wood destillation, I think that it is on a large-scale level. I am not aware of any recent feasibility studies for wood destillation plants.

5.3.3 Alcohol. The production of alcohol as a biofuel is not different from the production of spirits. Raw-sugar containing materials are fermented and the alcohol is separated by distillation. No reliable information is available on the feasibility of small-scale alcohol production to be used as a fuel.[452] A priori, it may be expected that the fact that alcohol is also an alcoholic beverage, makes the social viability of small-scale production low. In view of the energy crisis the large-scale production of alcohol to be used as an additive to petrol fuels and as a feedstock for the chemical industry has recently gained much attention. Typically, in November 1975 Brazil's National Alcohol Programme was launched, which aims at saving US$ 500 million per year in foreign exchange credits on the importation of petroleum. Distilleries will be attached to sugar factories or will have their own cane field estates.[453]

5.3.4 Anaerobic digestion. This is one of the most overworked suggestions in the literature on "appropriate technology". 'It is believed that the completion of some development work now in progress will make it possible for farms and ranches to install digestion tanks', wrote Buswell in 1930.[454] After ten years of writing and lobbying in 1957 the

452. See NAS (1967, pp. 180-190) and Merrill and Aston (1975) and references given there. See on alcohol as a byproduct of the sugar industry ref. 16 in note 442. In large scale production the effluent treatment is a major problem: See Jackman (1977).

453. Other crops considered as input are: cassave, babassu (a fast growing nut), and sorghum.

454. See ref. 1 in note 457. Similarly, just after the second World War in Western Europe (refs. 34 and 23): 'Wegen der groszen volkswirtschaftlichen Bedeutung der beiden gekuppelten Verfahren der Treibgas- und Humusgewinnung ist dringend geboten, schnellstens solche Anlagen in groszen Umfange zu errichten und zu betreiben.' (Schimrigk, 1950.) 'Nous pouvons conclure que le gaz de fumier est un carburant rural qu'il ne faut pas négliger et souhaiter que des essais bien étudiés montrent aux agriculteurs...' (Carré, 1947.)

Gobar Gas Scheme was started in India and a research institute to design digestors and such was established. Scores of digestors have been developed (i e drawings exist that are now circulated all over the world). There are rumours that of the 4000 (or 8000 or 30,000) Gobar biogas plants installed with government support[455] only 30% are in operation. However, it is not possible to obtain any pertinent, let alone reliable, data.[456] Nevertheless we are flooded with "eureka" statements regarding some secret black box which produces methane out of organic waste. As I am presently writing a review article on small anaerobic digestors I shall not here discuss the literature[457] or the prospects of this production system. I just mention a few of the most important and overlooked factors:

(a) The interest in anaerobic digestion may derive from three very different angles: (i) waste treatment problem, (ii) energy production,

455. By far the most digestors in India have been installed by the KVIC. 'There has been a feeling that the farmers agree to the installation of the gas plants sponsored by KVIC generally due to the financial assistance accorded for the same purpose. There has been no evaluation of the utilization of the gas plants so installed' (ref. 69 in note 457).

456. More seriously, AT-adepts talk a lot about these digestors, without being interested in performance data and without wondering why these data are not available. I would not be amazed if at present, only in, for example, the UK, at least 40 groups are now "actively" engaged in anaerobic digestion. (Everybody seems capable of doing research on this subject: architects, electrical engineers, drop outs.)

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(iii) fertilizer production. Almost all R & D has been directed to (i), hence it is certainly worthwile to investigate the possibilities of (ii) and (iii) further: A brief look at the 70-year old history of these digestors will show however that it is not a simple production system.

(b) It is now being very slowly realised that one should forget about biogas plants as an energy source for rural areas. If there is any future, it is for bihugas plants - that is production systems which have as output firstly natural fertilizer, and secondly methane.

(c) Present designs of small-scale digestors (2-10 m3/day) are only technically feasible when operated at a constant temperature; small-scale digestors operating at constant temperature are economically certainly not feasible unless the price of the surplus sludge is very high. Research should concentrate on the microbiological and technological *possibility* of small-scale digestors without heat exchangers.

(d) On the spot construction of small-scale digestors is socio-economically not feasible. Research should concentrate on the possibility of large-scale production of cheaper construction materials (rubber bag digestors, etc.).

(e) Medium-scale (10-100 m3/day) constant temperature digestors for rural application seem possible, provided the (social) infrastructure is favourable to handle the transport problem. A detailed survey of existing knowledge on these systems is necessary.

5.4 Health

5.4.1 Pharmaceuticals. In most LDCs inventories have been made of indigenous plants having medicinal value. Many departments of organic chemistry in universities and government research institutes do research - at least according to the annual reports - on extraction from plants of alkaloids and other drugs. Due to the small-scale on which R & D is carried out, and lack of the necessary sophisticated equipment not much progress has been made.

Because in many countries the extracts of plants and herbs are used in traditional medicin, there is an urgent need to improve these traditional techniques. It is, however, difficult to judge whether there is a possibility of small-scale drug production that fulfils the standards of western medical practice. Most conventional drugs ask for sophisticated production systems,[458] but there is certainly scope for small-scale preparation of drugs (as a tablet, capsule, etc.) from the constituting (imported) chemicals.

5.4.2 Soap. Soaps and detergents are mainly used for household purposes and the types can be grouped under toilet soap and laundry soap. The production of laundry soap from natural sources has sharply decreased with the global spread of synthetic detergents.[459] Although the choice of synthetic detergents favour capital-intensive multinational production, they do not use edible oils. A plea for using natural soaps should therefore imply using non-edible oils.

Production of soap on a family scale is age old. To make soap one basicly needs a vegetable oil and caustic soda (plus additives in small quantities). Recently, there has been an increase in the exchange of leaflets on how to make your own soap. The appropriateness of this seems disputable. A lot of the time of volunteers is continuously spent on making these leaflets; furthermore, caustic soda is a nasty chemical and therefore small accidents will counterbalance the universal spread of home-made soap.[460] The production of soap on a

458. It is well-known that in the conventional pharmaceutical industry technology is sophisticated, costs of licensing are extremely high, and economies of scale are high as well. It is very difficult to evaluate what possibilities there really are for LDCs to produce the drugs (i.e. the chemicals) themselves. It seems to me that the pharmaceutical industry has a rather strong hold on the manoevring possibilities in this respect for organizations such as UNIDO and WHO.

459. Sulfated castor oil can be considered as the first synthetic detergent. The "older" synthetic detergents still use vegetable oils as input. However, today, more than 70% of the synthetic detergents are made from petrochemicals, in particular alkyl benzenes.

460. 'Sisters... This soap recipe is a great improvement over the one recently printed, which was incorrect.' (recent leaflet of "Sea Side"). It may be stressed once more that as far as promoting traditional production systems are concerned, there is nothing really new in the new look. For example in 1934, David wrote in "Soap making on the farm": 'Making soap is a simple matter. It is the manufacture of special soaps that has been the object of experimentation by chemists for many years. But all their interesting discoveries about soap manufacture with coconut oil as the fat are of little value to the Filipino farmers or others who wish to make a usable cleaning soap with the cheap coconut oil.'

small-scale (for one village or small city)[461] is however quite appropriate and offers a good example of the way indigenous small-scale production is hampered by the transfer of tastes and products from overdeveloped countries to LDCs. I shall briefly discuss two examples.

TCC-Kumasi developed and commissioned a number of small soap plants in Ghana. The first prototype plant started production in 1973. During the first two years of operation, the price of palm oil, the principal raw material, more than doubled, whereas the government controlled retail price remained fixed. The other raw material, caustic soda (or soda ash),[462] is often difficult to obtain due to transport problems and import restrictions. 'During the period, September, 1974 to March, 1975, the market in Kumasi appeared to be flooded by Lever Brothers 'Key' soap .... Sales were maintained only by selling in surrounding towns and villages on market days. Then, in April, 1975, Key soap disappeared from the Kumasi market and at once the demand for Anchor soap far exceeded the capacity of the prototype plant.'[463] The prospects of Anchor soap seem doubtful as long as Lever Brothers is around.

In Kenya small- and medium-scale indigenous soap production was well-developed, but is now in a process of decay or modernisation due to the competition of the multinationals. 'Advertising, then, has been crucial in generating local demand for sophisticated, well-packaged, mnc-type products - with their associated employment and linkage weak-

461. See on the economies of cottage soap in India: Prasad (1963). Lever Brothers developed a number of (large-scale) processes to make household soap from non-edible Indian oils, thus reducing imports of edible oils in India (Veldhuis, 1977).
462. Caustic soda (NaOH) is mainly produced by electrolysis of salt (NaCl) on a large scale. When very cheap hydro-electric power is available, small-scale electrolysis is perhaps possible, but in LDCs there is usually no significant market for the second product,chlorine. The normal small-scale production of NaOH is from slaked lime, $Ca(OH)_2$, and sodium carbonate. This is a reasonably simple process. Lime is available on many places. But sodium carbonate or soda ash not. A number of plants and sea weeds when carefully ashed give soda ash with a high concentration of sodium carbonate in it. Precise identification and location of possible sources of soda ash and the development of efficient production systems for small-scale production of NaOH may be of some use.
463. This paragraph is based on TCC-Kumasi (1975). The plants commissioned in 1975 had capacities of 250-500 bars-a-day. See also note 325.

nesses.'[464] The advertising has hardly affected the total sales of soap, only product subsitution, in particular for laundry soap for which consumers pay more to get a machine-made product that is inferior in everything but appearance.

5.4.3 Water.[465] The literature on water catching, storage, and treatment systems for LDCs is - compared to other objects - well documented and accessible and I shall not review the subject.[466] This is not to say that all "water"-systems nowadays installed are appropriate: Very many of the water-projects in rural areas of LDCs are carried out under supervision of the WHO.[467] There exists no system of evaluation of these projects and because the people who design and install systems usually do not see the system operating for a few years, there is little possibility for learning from experience. Because the product

464. This paragraph is based on Langdon (1975). It is the smart-looking packaging that requires mechanization. By world standards the capital requirements are small for these apparatuses. But for indigenous entrepreneurs who have no easy access to capital, let alone foreign exchange, this forced change is often unsurmountable. In the non-mechanized firms the most capital-intensive operation is the drying stage. As Pack (1976) notes indigenous firms have developed various "innovations" to reduce capital intensity in modern processes, e.g. using bin-drying in stead of spray drying of detergent-noodles. Although local firms are more labour-intensive, it seems to me that it is more important that they use less capital (both local and foreign) for the same output. Other advantages of the local firms are: they use a greater proportion of indigenous raw materials (and are in fact better equipped to do so); they contribute to regional decentralization (outside Nairobi there are indigenous soap factories in seven cities; all three multinationals have their factories in Nairobi). In contrast the multinationals add to the growth of a labour aristocracy (by paying higher wages) and an African bourgeoisie that can invest in highly-profitable enterprises. There is considerable evidence that the latter favours the economic structure for multinationals, in particular through the tax structure.
465. A chemical product that can be derived from the need for water is active carbon. Active carbon can be processed from quite a number of agricultural wasbtes. The production from coconut shells is rather well established.
466. See for a summary of water treatment and sanitations to be used in rural areas for example Mann and Williamson (1976) or Van Gorkum and Kempenaar (1975). See for a summary of rainwater catchment and storage systems: Maddocks (1975).
467. See on IRC-WHO note 363. IDRC has plans to establish an "Appropriate Technology Water" journal. Moreover, there is very little R & D, or innovation in the systems choosen in or for LDCs. A few institutes are involved in selecting local filter media, but this seems to be a marginal activity.

needed is the same everywhere and there is almost no effect of world markets, the production of water is a rather ideal production system. Perhaps that is the reason that sanitary engineers seem to be more conservative than others.

5.5 Shelter

5.5.1 Building materials. Low-cost housing programmes are now being carried out in virtually every LDC. Often, the results appear to be inappropriate. Firstly, the emphasis is on the urban sector, and stimulated by the rapid growth of the urban centres. If, however, shelter facilities in rural areas would be improved to the level of more permanent dwellings, which have some capital value, this might well help to reduce the track to the cities. Secondly, the designs and choice of building materials are often not in concordance with given climatic and social environment (the most typical example probably being the use of corrugated iron roofs in the tropics).

The emphasis in this section is on cementitious materials,but from the following list of other problem areas in building technology, it can be seen that (semi-)chemical production systems play a role in a number of other respects.

(a) One of the oldest building materials is mud. Thick mud walls have the advantage of being very effective in damping temperature fluctuations in tropical regions.[468] Maintenance costs can be reduced and life time increased, if the walls are treated with water-proofing substances - which, in principle,can be obtained from various natural sources.

(b) If wood, or wood waste is used as, or in, construction materials, there is usually a need for adhesives, fungicides, and paints or varnishes. For all three of these chemical products there exist both natural resources and synthetic substitutes: There seems to be conside-

468. See for data on temperature fluctuations in a mud brick room and a prefabricated concrete room Cain et al (1975). They also draw attention to the traditional techniques of making vaults and domes from mud bricks - which often are the most appropriate roof constructions at places where wood is not abundant.

rable scope for improving traditional production methods for natural products.[469]

(c) Over the past ten years there has been a significant increase in making and using wood-wool slabs and particle boards from a variety of waste materials.[470] In both cases adhesives are necessary,which preferably are to be extracted from natural sources. It may be noted that, because of the high pressures needed, particle boards and wood slabs ask for rather capital-intensive production systems.

(d) At many places R & D is carried out in finding an optimum in brickmaking between the quality required and the degree of mechanization. Transport between process stages can be done by hand and sun drying, wherever there is sun, is most appropriate. Problems are (i) low mechanised milling/mixing/moulding which guarantees quality, and (ii) feasible small-scale kilns. The Indian Central Building Research Institute claims that continuous kilns of 15,000 bricks a day can be competitive.[471]

(e) Cementitious materials. These are used mainly for mortars in bricklaying, for making floors, and as soil stabilizer in making roads. The Egyptians used burnt gypsum; in Greece and Crete the process of slaking lime was developed. The Greeks also discovered that by adding some form of siliceous matter (puzzolan) to the lime mortar the strength can be increased considerably. Present day cement is a recent invention made from lime, clay, and gypsum at high temperatures. I shall briefly discuss the production of lime, puzzolanic materials, and the economies of scale of cement production.

5.5.2 Lime production. Lime burning is here discussed as an input

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469. Kulvik (1977) gives a good "review of past research on utilization of naturally occurring organic products as replacement of synthetic phenolics in wood adhesives" with 89 references.
470. NRDC-India licenses processes for making particle boards from coconut husks, waste cork granules, leather waste, saw dust, cassave stalks, paddy husks, groundnut husk, etc. TPI has a large R & D programme on both particle boards and wood-wool slabs.
471. See Spence (1975) and Behari (1975c). The kiln is a local adaptation of the Hoffman kiln and coal is used as a fuel. Below 10,000 bricks per day intermittent kilns have to be used which use much more fuel. When fuel is available abundantly, good quality bricks can be produced at a scale of 10,000 bricks a week.

for shelter providing systems: it may be used in building mortars, in lime-clay blocks, and as paint (lime-washes). As a chemical it is an input for many other production systems.[472] Lime burning is carried out on a family- and small-scale in almost all the numerous LDCs where there are limestone deposits. As an alternative to cement lime has both a number of advantages and disadvantages. It is beyond dispute that, in particular for rural areas, in principle the production of lime (on a small-scale to save transport costs) is most appropriate.[473] The problem is that in practice the performance of the small-scale production systems is very far from what is possible in theory. The major problems are:

(a) Due to inappropriate kiln design and the absence of controlling mechanisms during operation, the quality of the lime is low and varies considerably from one day to another.

(b) Due to inappropriate kiln design the firing efficiency is very bad.[474]

(c) Due to inappropriate kiln construction, the kiln is often destroyed due to cracking.

(d) Due to varying quality and output, it is not possible to acquire a stimulating market for the product.

(e) Traditional practitioners are usually 'too conservative to be prepared to alter their well-tried methods, even though the greater efficiency is obvious.'[475]

Apart from the last aspect which is of a different type, some R & D on small-scale lime manufacture seems most appropriate in view of the millions of dollars the Portland Cement manufacturers invest annually in

472. Lime is used in water treatment, paper and sugar making, for the production of soda ash (cf. note 462), as a tanning agent, etcetera.
473. Small-scale kilns have a capacity of 5-25 tons a day. Lime kilns available from manufacturers in industrialized countries have a capacity of 50-200 tons a day.
474. It may be noted that the theoretical heat requirements are far outweighed by heat losses arising from evaporation in drying slurries, radiation losses, and fluegas losses.
475. 'Recent work by Indian research institutes has revealed the great inefficiencies in some of the traditional practices, and more efficient manufacturing methods have been developed. Traditional manufacturers have, however, been slow to adapt improved techniques.' (Spence, in: ITDG, 1974a.) One of the improved kilns has been developed and is promoted by the KVIC (cf. section 4.4.2).

R & D to achieve the greatest possible utility and versatility for their product. In the past five years or so "prototype lime kilns" and similar projects have been set up all over the world.[476] Some coördination or exchange of experiences may be useful.

5.5.3 Puzzolanas.[477] A lime mortar sets slowly and never develops much strength. A puzzolana is a material, which, when mixed with lime and a little water, sets to a solid.[478] Although a lime/puzzolana/sand or rock aggregate mixture gains strength more slowly and has a lower ultimate strength than if Portland cement is used, it has several advantages:[479] Puzzolana based constructions have a greater durability when exposed to corrosive conditions, they are less permeable, they are easier to work with, and better accommodate thermal and shrinkage stresses.[480] Moreover burnt clay puzzolana has the great advantage that instead of the about 1500° C necessary in cement-making it only requires temperatures up to 800° C to be made. This implies lower investment and fuel costs and therefore being less susceptible to economies of scale. The major problems hampering an increase in the use of puzzolanas are

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476. Field trials take place in Ghana (Ellis, in: ITDG, 1974a), Botswana (Fewster, in ITDG, 1974a), India (Central Building Res. Inst. and National Buildings Organization; see references in Spence (1974) and Behari (1975c)), Indonesia (UNDP, 1977a), Honduras (Bury, 1975; this is a VITA-project, cf. section 4.5.3), Papua New Guinea (PNGUT, 1974), and probably many other places. (I have noted plans for field trials in Tanzania (ITDG, 1975) and Nigeria (Howe, in: ITDG, 1974a). LDCs where simple lime kilns are used further include: Colombia, Seychelles, Iran, Ethiopia, Somalia, Sri Lanka, Malaysia, Korea, China.)
477. See on puzzolanas the papers of Coad, Gaze, Forrester, Bain, and Spence in ITDG (1974a) and references given there. See for activities in India also Behari (1975c).
478. Materials having puzzolanic properties are: glass, zeolites, opal, calcined clays, and bauxite. In practice only the following have been used in considerable quantities: tuffs and ashes of volcanic origin (Italian pozzolana and German trass), and burnt clays (Egyptian homra and Indian surkhi).
479. Apart from the lime-puzzolana mixture as a complete substitute for cement, puzzolana can be added up to 20-25% of cement without significantly affecting the properties.
480. 'The mortars and renderings of many of India's magnificant ancient buildings were made from lime-surkhi and are still in good condition; and from the nineteenth century until the present day much use has been made of lime-surkhi for canal and dam works since it is less liable to shrinkage, more impermeable, and better accomodates internal stresses than do cement-based mortars and concretes.' (Spence, 1974.)

most probably:[481]

(a) Very little research has been carried out on the mechanisms of puzzolanic behaviour. Assessment of different raw materials and finding optimum reaction conditions is therefore difficult.[482]

(b) In present practice lime and puzzolana are mixed on the site with possibly variable results. The alternative of first hydrating the lime to a dry powder and then intergrinding with puzzolana has hardly been investigated.

(c) As yet there exist no tests that can be used to assess the usefulness of the great variety of puzzolanic materials.

(d) Fine grinding of the burnt material is essential. Small-scale grinding apparatus (ball-mills) is relatively expensive.

(e) Design of small-scale kilns offering a good temperature control is on a similar level as for lime production. (Theoretically, requirements for lime burning and burnt clay puzzolana are different, but it is possible that the same type of vertical shaft kiln can be used.)

5.5.4 Small-scale cement production. Due to strong economies of scale, small-scale cement manufacture is, a priori, only possible if transport costs outweigh the higher costs.[483] For various reasons medium-scale cement factories in LDCs (using rotary kilns) produce at higher costs than the large-scale factories in industrialized countries.[484] However in remote areas far from the sea transport costs may be high for large-scale production and then small-scale production may be feasible.

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481. At present puzzolana-cement cannot be produced much cheaper than cement in India. It can however be argued that the official price of cement is kept artificially low.
482. 'Little effort has been expended in relating type of clay to pozzolanic behaviour and consequently the assessment of a deposit from the nature of the clay component is fraught with uncertainty,...' (Bain, in: ITDG, 1974a.) 'The study ... provides a good example of the care with which such materials should be approached...' (Gaze, in: ITDG, 1974a.)
483. Around 1960 quite a number of small shaft kiln cement plants were established. See e.g. Hughes (1956). Due to a breakthrough in rotary kiln technology (of the dry-process four-stage suspension preheater kiln) cement prices went down and the shaft kilns disappeared.
484. In a detailed comparison of a cement factory in Indonesia and the USA it appears that the main reason for higher costs in Indonesia are (a) social overhead (50% of investment) that was already available in USA, (b) extra provisions for keeping and making spare parts, (c) higher governement taxes. (Doyle, 1965.)

It is reported that in China 3000 small-scale shaft kilns are in operation (3,000 - 50,000 ton a year), producing half of the national output. The quality, however, seems to be very low and the cement can only be used for plastering and jointing and not for roofing and flooring. On a small-scale, rotary kilns cannot be used, whereas shaft kilns are much more difficult to control to produce high-quality cement. There are various reasons why there has been, on average, little R & D on improving shaft kilns. Technically it is certainly not an impossible task to design a kiln which operates appropriately.[485] It is of course another matter whether it can be operated appropriately and economically in a given context.[486] There are a number of coal-fed shaft kilns in operation as part of small cement works, but it is difficult to evaluate how much protection they need and for how long.[487] Because of accessability of technical and economic data on cement plants, it is very difficult to judge whether small-scale cement production is feasible.

485. See on the problems in the design of shaft kilns: Blenkinshop (in: ITDG 1974a) and UNIDO (1977f). In the latter publication a newly developed flame-fired push-car kiln is mentioned, which may have a promising future for small-scale cement plants. It is further estimated that the minimum economic scale is at present 80,000-120,000 ton a year and notes that 'Small-scale cement plants may meet with opposition from large-scale cement producers as a network of shaft kilns in some areas could create competition for their markets.' Of course 'undoubtedly there is a great deal of information within the major cement companies of the world on the operation of shaft kilns for the production of Portland cement...' (Blenkinshop); the problem is that it does not come into the open.

486. In 1967 Ramachandrau of the Tamilnad Cement Factory writes: 'A small cement plant producing clinker from the smallest shaft kiln in the world started production in India in August 1966.... The high thermal efficiency and low cost of the plant have shattered the theory of big-sized plant economy.' This looks promising. Over the period 1972-1976 the Cement Research Institute of India developed a mini cement plant which started continuous operation in July, 1976. 'In a favourable situation a net return of over 16 per cent is anticipated on the capital.' (Visvesvaraya, 1977.) This also looks promising. However, in the latter publication it is also recorded, without further comment, that 'a sick mini plant attempted as a pioneering one by the Government of Tamil Nadu State in India in 1966 was gifted to CRI in June 1974 for R & D studies.'

487. UNIDO (1977f) gives data on shaft kilns in operation in Kenya, Nepal, and India.

5.6 Miscellaneous

5.6.1 Introduction. There are a large number of chemical production systems that have not as yet been discussed which fulfil some basic need; these include chemicals used in production systems discussed in the previous sections and a number of consumption goods; or which fulfil the need for a real income for the rural areas. Typical examples are the production of natural dyes; of ceramic[488] and plastic[489] household products; of glass products; of chalk, ink, and paper; and essential oils. To keep this inventory within limits I make only a few remarks on paper and essential oils.

5.6.2 Paper. The problems in appropriate pulp and paper production fall apart in two classes: (a) the use of local woods and other ligneous raw materials of indigenous origin for the manufacture of pulp and paper, (b) the feasibility of small-scale (5-20 ton per day) and medium-scale (100 ton per day) production systems.

As to the first, of course, pulping processes have primarily been used and developed in Europe and North America, where the raw fibre material mainly consists of conifers. Tropical countries normally lack conifer woods, but they usually have many other kinds of fibre raw materials: hard wood, bamboo, straw and husks, bagasse, various grasses. Although all these raw materials are used for paper making in one place or another, [490] only bagasse is processed in significant quantities (estimated to yield one per cent of the world paper production). Typically, the first attempts in making paper from bagasse assumed that bagasse would behave like wood and it was concluded that bagasse gives low yields and poor quality paper. It was only much later that it was thought worthwile to consider the possibility of adapting the well

488. Garg (1974a) gives an interesting description of the PRAD project for "scaling up" the production systems used by the village potters in India, who are working for a declining market. As usual the problem is that the 'financial background of the users of scaling-up efforts is too low to initiate the adoption of the new technology on their own.'
489. There is moreover a strong increase in the use of plastic for agricultural tools. Processing plastics is more or less by definition, capital intensive. Such production systems therefore only serve import substitution and give no significant employment.

known processing steps to the particular input used. R & D on paper making from various raw materials is a good example of an activity that can be carried out anywhere in the world and is useful for any country processing the particular raw material.

Small-scale paper prodcution is most widespread on the Indian subcontinent and in the Far East. In India the stimulation of the handmade paper units is one of the main projects of the KVIC. It is reported that over the last 15 years the number of units has increased from 110 to 180, which, of course does not provide significant employment. The small-scale handmade-paper units can only produce for special markets and hence there are no possibilities of spectacular growths. However, in principal, there seems scope for a spectacular growth of small-scale processing of waste-paper, which could be economical at 3-10 tons per day. In the literature there seems to be agreement that for production

490. UNIDO (1977) gives the following inventory of successful experience: (a) Bagasse usage and pulping (Peru, Colombia, Cuba, Iran); (b) straw usage and pulping (Egypt, Algeria, Sri Lanka); (c) Eucalyptus wood pulping (Brazil); (d) Bamboo, jute pulping (India, Pakistan, Bangladesh); (e) Waste paper usage (Egypt, Philippines, Thailand); and (f) Esparto (halfa grass) pulping (Morocco, Tunisia). But this is probably not complete. Garrana (1976) mentions successful industrial pulping of bagasse in Egypt and there is definitely also experience in India. Although Japan is not an LDC, its experience in processing bamboo and rice-straw seems relevant. Rice straw is also processed in Indonesia and Taiwan. Attempts in the Sudan to process papyrus were not successful. Much information of pulp and paper processing of tropical raw materials is available at TPI.

491. Short bibliography on small- and medium scale paper production (compiled by G.J. Keilman): 1. C. Th. Davis, The Manufacture of Paper, New York (1972, reprint of 1886); 2. Pulp and Paper Manufacture, New York: Mc Graw Hill (1969); 3 Handbook of Pulp and Paper Technology, New York: Rheinhold (1964); 4. J.E. Atchison, Science 191 (1976)768; 5. V.W. von Hagen, The Aztec and Maya papermakers, New York(1944); 6. J.M. Paturau, By-products of cane sugar industry, Amsterdam (1969); 7. D. Hunter Papermaking through eighteen centuries, New York(1930); 8. J. Bekk, Het Papier, Amsterdam(1952); 9. C. Th. Kokke, De Veluwse Papiermolen, Arnhem(1974); 10. H. Voorn, Papierfabricage in de eerste helft van de 19e eeuw, De Haag(1975); 11. Articles in TAPPI, Non-wood plant fiber pulping, starting 1970; 12. W. Raitt, The Digestion of Grasses and Bamboo for Papermaking, London(1931); 13. UN-FAO, Pulp and Paper Development in Asia and the Far-East, Bangkok(1962); 14. K. Greferman, Thesis, Hamburg(1964); 15. UN-FAO, Pulp and Paper Development in Africa and the Near East Cairo(1965); 16. H. Drissler, Papier 23 (1969)713; 17. H. Seibert en K. Bahr, Papier 24(1970)331; 18. H. Voorn, Papierwereld 23(4)(1969)95; 19. Khadi and Village Industries Commission Handmade paper project report, Bombay(1975); 20. various articles in Indian Pulp and Paper, in particular 16(1)(1961)93-108, 28(4) (1973) 13-16; 21. Papers presented at UNIDO Expert Group Meeting on Pulp and Paper; Vienna 13-17 Sept. 1971; 22. V. Podder 'A Guide to Manufacture of Paper in a Small Scale' Rohtas Industries Ltd., Dalmianagar, India (1960); 23. S.R.D. Guha, Indian Forester, 101(1975)192-197; 24. R. Eklund. Unasylva, 21(1967)17-27.

492. Due to rising oil prices, synthetic substitutes for essential oils tend to become more expensive (although one would not predict that on the basis of a simple cost calculation).

493. Selected bibliography on essential oils (compiled by A.S. Bos):

1. Guenther, The essential oils, vol. I - IV, Van Nostrand, New York, 1948 - 1950; 2. R.M. Gattefosse, Distillation des plantes aromatiques et des parfums, Librairie centrale des sciences, Parijs, 1926; 3. M. Fölsch, Die Fabrikation und Verarbeitung von ätherischen Olen, Hartleben's Verlag, Wien und Leipzig. 1930; 4. Papers of the Conference on Essential Oils Production in Developing Countries, TPI, HMSO 1968; 5. G.R. Ames & W.R.A. Matthews, Tropical Science. 10 (1968) 136-148; 6. R.P. Hildebrand & M.D. Sutherland, Chemistry and Industry, 32 (1956) 828; 7. E. Browm & H.T. Islip, Colonial Plant and Animal Products, 3 (1952/3) 287; 8. G.R. Ames et al., Bay oil distillation in Dominica, Tropical Science, 13 (1971) 13; 9. J.A. Pickett et al., Chemistry & Industry, (5-7-1975), p 571-2. 10. G. Igolen, Soap. Perfumery, Cosmetics, (April 1969) 265; 11. UNCTAD/GATT, ITC/MR/2:210, December 1969.

systems involving a pulping process the minimum scale is in the order of 150-250 tons per day - and even then needs tarriff protection.[491]

5.6.3. Essential oils. These oils are mainly used in cosmetics. Although they are usually considered an interesting export product,[492] there is as often a considerable demand on the local market for soaps and perfumes. The essential oils, such as peppermint, sandalwood, eucalyptus, and bay oil, are extracted from leaves or other plant materials with water. To obtain a high efficiency and a constant product-quality steam distillation is used. Traditionally, simpler techniques are used such as boiling in water. There is a tendency to displace all family scale low-quality "boiling with water" systems by medium-scale steam distillation plants(sometimes operated by cooperatives). I think more attention should be given to the intermediate technique of having the steam of boiling water pass through the plant material. As is the case with other extraction processes (for edible oils, drugs, insecticides), extraction should be carried out as quickly as possible. This, therefore provides an inherent advantage to produce on a family- or small-scale; the product has to be processed further, but is at least stable. Further, there are considerable potentials for improving the traditional techniques, without very much increasing scale or degree of sophistication.

6. UNIVERSITIES AND APPROPRIATE DEVELOPMENT

6.1 Cultural dominance

The notion of economic imperialism is well-known and is a basic concept in "dependence" theories (cf section 2.1). The notion of cultural imperialism is less known. Cultural imperialism might be described as a form of religious and secular evangelism. The role of universities as a means of cultural imperialism cannot be underestimated. This role is different for ODC-universities (universities in overdeveloped countries) and for LDC-universities. The latter have been set up as copies or dépendances of ODC-universities and are isolated outposts of the western culture in an environment within which there is virtually no interaction.[501] ODC-universities support this phenomena via cooperation projects. Apart from that, ODC-universities engage in various types of

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501. See also section 2.2.3. It should be stressed that the isolation of LDC-universities from the production systems in their environment is not a recent discovery. A very early example is from Egypt: 'The Role of the Egyptian University in research goes back to 1925 when the first University namely Fouad University was established in Cairo. The Fouad or the Cairo University now, has been followed by numerous other Universities until the number of universities now reached eleven. The number of staff involved in research work in these universities amounts to many thousands. Industrialization started on the other hand in Egypt at a later stage. The Egyptian Industry depended mainly on imported production units as well as imported technology. The import of technology was mainly in the form of employing foreign experts and technicians, license and know-how agreements, acquiring patents and the like, disregarding the research facilities available at the Egyptian Universities.' (Garrana, 1976), whereas before the war staff members of Egyptian universities already published letters in *Nature*.

development research which gives a strong backing to the academic imperialism of ODC over LDC-universities.[502]

In setting up LDC-universities as copies of ODC-universities two effects have been predominant: First, the humanities and the theoretical sciences far outweigh the applied sciences and the technical disciplines. Secondly within the humanities the western cultural tradition far outweigh any other cultural tradition. Typically, the University of Ibadan (Nigeria) had been running courses in Latin, Greek, and medieval European history, long before it recognised the need for engineering, economics, or geology; and long before it was discovered that the Muslim community in Nigeria runs into millions. This, of course, has considerably helped a process of acculturation and hence the formation of a market to sell the cultural and economic products of the western culture.[503] This acculturation also supported the idea that the non-western worker was not suited to work in western production systems (and hence should be adapted), passing over the fact that there has been a continuous historical process of mutual adaption of western workers and production systems.[504]

LDC-universities are copies of ODC-universities, because they have

502. Streeten (1974) offers a good discussion of 'the limits of development research' and lists five main charges that have been made by LDCs against research on their problems: '(1) academic imperialism, (2) irrelevance, inappropriateness and bias of concepts, models and theories, (3) research in the service of exploitation, (4) domination through a superior and self-reinforcing research infrastructure and (5) illegitimacy.'

503. Mazrui (1975), from which a number of ideas in this section have been derived, states that 'During the colonial period the most immediate goal for western education in Africa was to produce culturally relevant manpower. But at least as important an enterprise was to expand a culturally-relevant market for western consumer goods, ranging from toothpaste to automobiles, from ready-made western shirts to canned tuna fish. The significance of the African university for commercial multinationals lay in these two areas of producing manpower and redefining the market through acculturation.' I would say that producing manpower was not a major concern of those interested in production systems; certainly not academic manpower. This is supported by the neglect of the applied sciences.

504. It could be added that in many LDCs graduates from universities can get no work, whereas there is a shortage of technicians and qualified lower level administrators. Together with the fact that the cost of one year of academic education for one student in the poorest countries is in the order of the annual income of 100 farmer families, this makes the whole concept of an LDC-university a little bit complicated.

been set up by people from ODC-universities and they remain ODC-copies because that is where their peers are. Entrance, examination, and appointment requirements[505] should be the same to fulfil the standards of quality. In larger LDCs this leads to competition between different universities: a competition concerned with who is best isolated from the surrounding culture. Because of 'the general acceptance of science and technology as vital levers essential for economic and social development',[506] LDC-universities are now acceptable substitutes for the golden beds of the past.

Of course the isolated position of LDC-universities and some of the negative effects they have, do not go completely unnoticed.[507] Measures

505. In the humanities the question of curriculae and appointments is even more relevant than in the sciences. See for example Mazrui (1975): 'The question which arises is whether there are specialists of oral history in African societies who can be appointed to university faculties without having a formal degree....Departments of sociology could have indigenous specialists in oral traditions; departments and faculties of medicine and preventive medicine could include specialists in indigenous herbs, and might even examine the medical implications of sorcery and withcraft as part of the general training of a rural doctor in Africa. African dance and music should be given a new legitimacy in all primary and secondary schools, regardless of the sensitivities of the missionary authorities in power.'

506. This opinion set the tone of a conference of ministers of African states responsible for the application of science and technology to development in 1974 (UNESCO, 1974). Notions such as appropriate technology or rural development do not occur in the proceedings, although, of course, it is recommended that 'African countries, in selecting new technologies, take into consideration the size of the country and the level of its technological development and import only those which are best united to local conditions in particular those which will benefit their people directly....' Although the 'highest priority [should be given] to the creation or strengthening of national universities', nothing is said about why this should be done, apart from 'training highly qualified personnel'.

507. In December 1976 UNIDO (1976a) organized an 'ad hoc expert group meeting on co-operation among universities, industrial research organizations and industries and the role of UNIDO in this cooperation.' UNIDO had asked all participants to give suggestions as to which role Unido could play in fostering this cooperation in developing countries. Almost all participants advized that UNIDO should organize symposia. Suggestions are further of the type that: 'The role of UNIDO should be to inform countries without experience and tradition in this respect about the advantages of scientific investigations and also to create an economically useful demand for such research in these countries.' (Maj, 1976). The most sensible suggestion - there should at least be one - is that

are taken to prevent brain-drain[508]: LDC staff members now have sabbatical leaves at ODC-universities.[509] Research is directed to the resources of one's own country: but still the chemical engineering department is established 10 years later than the chemistry department. The problems are noticed most clearly by the aid-giving countries:[510] The contents of cooperation projects between ODC- and LDC-universities *are* changing, due to the new look pressures in ODC-universities.[511] Whether this changes very much in the character of cultural dominance is doubtful.

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universities should not bother about research, but should provide industry with a steady supply of highly qualified engineers (Enahoro, 1976).

508. See for a review on the brain drain J. Dev. Econ.,2(3)(1975) and World Development, 3(3)(1975).

509. Consider also: 'To combat this tragic and potentially explosive situation the India Development Group, U.K. Limited has been formed by Indian professionals and qualified people, and other friends of India living in the U.K.... The members of the Group shall strive to provide intellectual leadership to the rural areas, which seem lacking at the moment... to try to interest Indian students and research scholars in the universities of the U.K. to work on projects related to the problems of rural development, instead of working on purely theoretical subjects;' (from a leaflet of VOCAD-London).

510. See for arguments against the involvement of western universities because of dependence and patronizing philantropism, inter alia Martinez (1975) and Akinrele (1975).

511. 'Niet alleen zijn de ontwikkelingslanden afhankelijk voor technologie van de industrielanden, doch ook de ontwikkeling van eigen research wordt in hoge mate bepaald door een probleem-gerichtheid welke niet de hunne is. Het onderwijs en in het bijzonder de wetenschappelijke scholing in de ontwikkelingslanden is vrijwel geheel naar het voorbeeld der ontwikkelde landen opgezet. Bovendien houdt men zich er te veel bezig met de problematiek zoals die zich in de ontwikkelde landen voordoet en die veelal afwijkt van de situatie in het eigen land. Dit heeft tot gevolg dat wetenschappers in de ontwikkelingslanden de problemen met een door de industrielanden bepaalde vraagstelling benaderen, hetgeen deze research vaak irrelevant maakt. Deze irrelevantie wordt nog versterkt door het feit dat een groot deel van de research die plaats vindt, fundamenteel in plaats van toegepast onderzoek betreft'. (Dutch Government, 1976a,p.68). There are not many LDCs who state it that way. The Dutch Government from now on only subsidizes development research that contributes to either the improvement of the conditions of the poor or helps to increase self-reliance. One wonders whether research on cultural dominance would fit their criteria.

6.2 Present appropriate activities at universities

Apart from the departments professionally interested in appropriate development such as economics and non-western sociology, the present-day activities related to "appropriate technology" are manifold and marginal at ODC-universities. For most S & T students at ODC-universities it is possible to follow lectures on "Technology and Development" or similar subjects, and sometimes it is a formal requirement to take part in a discussion of "Small is Beautiful". It is however rare when the contents of the lectures or discussion groups rises above the level of the information that can be acquired by reading the better newspapers.[512]

More fundamentally, even the more advanced courses exist in isolation. What this leads to is even more apparent from the plans at various universities of technology to establish chairs and institutes in "appropriate technology", or "technology and development".[513] All these activities have no bearing on the regular curricula. Provided the higher authorities provide the extra money, most departments and university staff-members think favourable of this "appropriate technology institution building." I think this institution building is not advisable if there is anything good in the new look. The effect will be that

512. It is often difficult to establish what is in fact happening and how much students take part in certain activities. For example, courses in 'Technology and Development' were started in 1972, 1975 and 1977 at Imperial College. Also: Since 1971 scholarships in appropriate technology exist at the University of Edinburgh, Faculty of Engineering, leading to a Masters Degree with possible extension towards a Ph. D. Subjects include: application of pedal power to agricultural processing equipment, use of tropical agricultural wastes as industrial input. However, in 1975 'a proposal is being written for the establishment of a small group at Edinburgh to study certain aspects of appropriate technology' (minutes of the 7th meeting of the ITDG forestry and forest products panel). It is certain that some activities are going on in these places for quite some time (personal observation), but the impact these have on their direct environment is very limited. Other institutes in Britain planning similar activities include: National College of Agricultural Engineering, Loughborough University of Technology.
513. Delft University of Technology plans the establishment of a 'multidisciplinary centre for appropriate technology' (Bemer and De Schutter, 1977). Eindhoven University of Technology has a subdepartment 'Appropriate Technology' since 1975 (Neggers, 1976), but it only caters for students in management science. See also notes to section 3.1.7.

special institutes (in appropriate X, Y, and Z) have the task of solving the problems that are created by the conventional departments; in the meantime the latter just continu their work. (That is to say: 98% of the university works on inappropriate technology and 2% on appropriate.)

The development in LDCs is similar: establishment of special centres (see section 4.2) which have little contact with the rest of the university. Courses in "appropriate technology" are given at most Institutes of Technology in India, but they seem to have more the effect of courses on the history of indigenous production systems, then having any practical relevance. In other LDCs there are at best post-graduate courses or courses dealing with an overview of the local (medium- and large-scale) industry. Cooperation projects between ODC- and LDC universities usually concentrate on institution building, i e establishing new departments. Due to lack of time or belief, the organisation and the contents of the curriculum is copied from the "mother". Research set up as part of the cooperation project, will by now be chosen on the basis of local priorities. Usually that is sophisticated research on production systems that have been established in the LDC on a turnkey basis. In the few cases where attention is given to more indigenous production systems, there are still a number of constraints, on which I will elaborate in the next section.

Via organisations such as ITDG, students and staff-members at ODC-universities deal with practical queries from LDCs. This certainly fulfils a need, but is not part of the official activities of the university. This has a considerable effect on the quality of the answers provided by well-intentioned encyclopaedia browsing students and overworked lecturers.(Not all lecturers are overworked, but those that are not, do not deal with these queries.) More recently larger cooperation projects between LDC-institutes and groups at ODC-universities, via intermediates such as ITDG and TOOL have been initiated. It is still too early to evaluate these projects, but I, for my part, expect a lot of tinkering together with a lot of publicity on the successes.

6.3 Constraints in working on appropriate production systems

6.3.1 A priori institutional constraints. Both for ODC- and LDC-universities, there are a number of factors that make them not the best places to work on appropriate production systems.

(a) Universities are institutes of higher education, they are not industrial entrepreneurs, management consultants, or social workers.[514] As I shall argue in the next section on possible tasks of universities, the first thing to do is to adapt the curriculum. Potentially there are many types of organisations that can be involved in developing, promoting, and introducing appropriate production systems; but there is only one institution that educates the engineers and economists that choose, design, and operate the inappropriate production systems. (This is true no matter what is considered appropriate and inappropriate.)

(b) Apart from educating students, universities are traditionally engaged in research. If we consider the 11 stages in choosing and introducing a production system, described in section 3.4, it is clear that universities can contribute only to small parts of this process, both in terms of the capabilities of the people working at universities and the organisational structure of which they form a part. If the other stages of the development process are not taken care of, universities will do more harm than good when trying to contribute. This is in particular so because of their status (normal people, who engage in some useful work and come across a problem tend to believe all the nonsense university staff members disseminate).

(c) Even if we restrict the discussion to the development stage of a particular production system, those production systems that are commonly considered appropriate do not fit into the institutional structure of a university. Usually no new scientific principles are involved, whereas a lot of practical, technical, and social experience is needed. This experience is not available and attempts to acquire it conflict

514. Most institutes involved in rural development or small-scale industry I visited in Africa did not see a task for either LDC- or ODC-Universities. Typical comments were: 'The problem is the process of change, not a technical problem', 'They want to try out their prototype in a village, but we cannot have such disturbances in the villages; we are only interested in production systems, that have definitely proved their mettle elsewhere'.

with the traditional institutional values. Information on traditional as well as modern small- and medium-scale production systems is difficult to acquire and unreliable. Universities used to sophisticated abstract and indexing services are not capable of dealing with all these down to earth problems.

6.3.2 Constraints at ODC-universities. As far as I can see there are three major arguments (apart from the inherent constraints mentioned above) against working on appropriate production systems at ODC-universities:

(a) By doing so the dependency of the LDCs remains. The cultural imperialism becomes more sophisticated by changing from the concept of "what is good for you is good for us" to the concept of "we know what is best for you". The opposition in LDCs against "intermediate technology" is largely a reaction against this change in cultural imperialism. Western universities being under various pressures from their own society, now have professors, who, instead of doing research for the Pentagon or Lever Brothers, travel around the world in the hope that they can sell the idea of trying out a prototype to some institution in a LDC, so that they can obtain a grant from their ministry of overseas development to further their career.

(b) For those in universities who have not yet joined the new look, the major argument "against" it is that interest in appropriate production systems is not compatible with the education of good scientists or engineers, because "appropriate technology" is a degenerated kind of old and simple "technology".[515]

(c) A less emotional argument against it is that it seems most impractical to take a problem from an environment 5000 miles away and start to work on it. It becomes very difficult to take into account the variables of that environment relevant for developing an appropriate production system (including the raw materials, energy sources, infra-

515. I think the previous chapter convincingly supports that this is definitely not the case. A completely different matter is that the activities as described in chapter 4 give ample reasons to support the old look argument. 'For Ethiopia appropriate technology is the only solution; however, it has attracted a lot of tinkerers and salon-idealists, such as the ITDG-club and the recycle freaks.' (Tebicke, Ethiopean Science and Technology Commissioner, 1976, personal communication.)

structure, political system, and the opinions and concerns of the people who are expected to operate and benefit from appropriate production systems in some unknown future).

6.3.3 Constraints at LDC-universities. Most of the constraints in working on appropriate production systems are related to the problem of cultural dominance described in 6.1 and the general contraints given in 6.3.1. Possibilities to do anything at all are very small!

(a) There is very little time for R & D work because of the high teaching load. In every descipline one to three staff members work in scientific isolation. Due to unreliable settings (electricity, maintenance) it is very difficult to do reliable experimental work.

(b) The staff is orientated to the "international scientific world." They know much more about M.I.T., than about the production systems of their country.[516] Rewards for staff members relate to academic degrees and publications, not to solving problems.

(c) Many of the common complaints about the practical relevance of the research carried out at ODC-universities apply in a greater measure to LDC-universities: Because there is no innovation or development in

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516. Illustrative of the level of interaction between LDC-universities and their industrial environment is the following: 'For example, a little over two years ago, I led a team of members of the National Executive of the G.M.A. at the invitation of the Kumasi University of Science and Technology to the University. We spent a whole day visiting the various departments working on research, and later on, had a meeting with the Board of Directors of the University and the heads of department. This was the first meeting of its kind between University and industry and it was very very fruitful. Through discussions we got to know of some of the problems facing them. They asked for financial assistance which we agreed to give as a group, and also promised to send out circular letters to our members for financial assistance. From the programmes of the Consultancy Centre they were trying to set up, we felt that this university is moving in the right direction for the promotion of indigenous industries, because effort was being made to develop industries around locally available raw materials. The second instance was when about six months ago the Food Research Institute had an 'Open Week' to the Food Group of Ghana Manufactures' Association. I being in Food Processing, felt highly impressed, but at the same time felt sorry that there were quite a number of products which were developed but could not be put to production. We therefore suggested to the management that the association would allow them a page in our magazine 'Ghana Manufacturer' for some articles on their work. I must say that we all found the two meetings fruitfull.' (Ocloo, 1976.)

the indigenous production systems, there is no complementary function for the universities. Staff members are not interested in team work and continue to work on the subject of their foreign Ph.D. Due to the system of values of the social group they are part of, they are even less reluctant than western scientists to dirty their hands or work in the sun.

6.4 Appropriate tasks of universities

6.4.1 Why "appropriate"? I restrict the discussion here to departments of universities concerned with production systems, in particular the universities or faculties of technology. I assume that there is something good in working on appropriate production systems at LDC-universities, because it seems sensible that they should be interested in subjects that are relevant for an appropriate development of their environment. I further assume that there is something good in working on appropriate production systems at ODC-universities because (i) by doing so they make interest in these areas a respectable academic activity, (ii) according to the World Plan of Action 5% of the non-military expenses for R & D in developed countries should be spent on work relevant for LDCs, (iii) for the methodology of a discipline, and for the appropriate transfer (to students or LDC-universities), it is of the greatest importance that the theories and methods of the discipline can be and are applied in very different circumstances.[517] In the following subsections I discuss more or less in order of importance the tasks universities can set themselves. There is a danger in calling them tasks because the current trend is to assign special parts of the university to carry out these tasks. The subject of discussion is a change in the content of the present activities, not an extra task on top of the normal work.[518] If, in particular at the prosperous ODC-universities, the only possible change is to ask for money to appoint new staff members to work in new institutes on appropriate problems, I think it is better not to do anything at all.

6.4.2 Support of technical and secondary education. Teaching science and technology at the sub-university level asks for cheap and appropriate teaching materials[519] and methods, as well as well trained people to do the teaching. It is only very recently that science courses at secondary schools started to make reference to indigenous resources and production systems.[520] There is still scope for considerable progress in this area. Further, I think it would have a good effect if LDC-universities would have some interaction with vocational schools in their environment.[521] Most important of course, are the people who give the lessons on the pre-university level. What did *they* learn from their university courses ?

6.4.3 Appropriate courses. There is a universal neglect of the difference between "knowledge" and "boundary conditions". It is true that the contents of pure science are the same no matter in which country or place it is applied. But to apply general knowledge, boundary conditions enter into the results. This can be illustrated in many

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517. Perhaps we might add that 'appropriate technology is a most useful way to bring a touch of reality to those faculties and departments not usually involved in social or global problems'(Congdon, 1974).
518. For some time now the UNO has tried to establish an international university and detailed proposals have been made to establish "development universities": 'Die Entwicklungsuniversität soll as Hauptinstrument der Wissenschaft der gesamtwirtschaftlichen Entwicklung dienen. Sie fungiert als Aktivierungszentrum für alle entsprechenden eigenen Massnahmen des Entwicklungslandes, die in den Bereich der Wissenschaft fallen und ihrer Unterstützung bedürfen; sie ist ferner Konzentrationspunkt für Verbindungen mit Institutionen und Organisationen ausserhalb des Landes, welche zur Realisierung des Zieles der gesamtwirtschaftlichen Entwicklung beitragen. ...Die Anforderungen, die an eine Technische Entwicklungsuniversität gestellt würden, sind fachlich stark differenziert und von erheblicher Reichweite: ihr fällt zunächst eine technische Aufgabe zu, indem sie die ihrem Umkreis und Wirkungsbereich entsprechenden spezifischen Entwicklungslinien der Mechanisierung, etwa in Agrarbereich, und der Industrialisierung erkunden und in einer den jeweiligen Umständen angepassten Weise durch eine geeignete Ausbildung und technische Forschung unterstützen und realisieren muss. Hierzu bedarf es einer intensiven Einwirkung auf den bereits bestehenden industriellen Sektor. Dabei ist die Berücksichtigung wirtschaftlicher und sozialer Konsequenzen durch eine fachliche Vertretung dieser Bereiche sicherzustellen.' (Havemann, 1973). I think this is the same phenomenon, but on a higher level, of putting the problem in a special box. Universities that could at present apply for the status of development university are possibly: University of Sussex, Indian Institute of Technology at Madras, and the Asian Institute of Technology at Bangkok. [The Asian Institute of Technology in Bangkok was established in 1959 and is 'the only institution in the region exclusively devoted to post-graduate teaching and research in engineering and allied fields.' It is financed mainly by the United States. At present it has a student body of about 400, which comes from more than 20 Asian countries.]
519. See on the state of the art of low-cost teaching materials DSE (1974).

ways. For example: the general laws regarding the elastic behaviour of materials have universal application. But there is no lecture on elastic behaviour that does not include illustrations referring to particular systems, and then it makes a difference whether one compares steel and plastic, or bamboo and wood. A second example could be a course on unit operations spending many hours of teaching on continuous distillation and chemical extraction, whereas nothing is told about batch distillation or mechanical extraction.[522] The reason for this choice is that in a certain class of production systems the latter two unit operations are hardly used. (The reason is not that the latter two are too simple; batch distillation, if anything, is theoretically more difficult to describe than continuous distillation.)

My point is not that from now on lecturers at ODC-universities should deal only with batch distillation in bamboo apparatus. The point is two-fold: (i) the distinction between what is always "true", and what is only true given certain presumptions or boundary conditions, should

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520. See on the teaching of chemistry in secondary schools in LDCs for example Allsop et al (1971), Hiebert (1971), and Barrow (1973). 'Science was introduced to us by scientists from the west; science has been taught to us, the peoples from the developing countries, by western scientists, and we have invariably received our higher degrees from western universities, especially the older ones, such as Oxford, Cambridge, and London. The result is that science in Africa has become an alien culture which is too irrelevant to the needs of Africa. ... In Africa, chemistry is pursued as proof of our intelligence or as a means of securing some safe job. All this had happened because we have never really stopped to consider why chemistry is studied at all or why we should teach it to our young men from year to year. The most important objective of teaching chemistry in developing countries is to secure a complete understanding of our immediate chemical environment, control it and use it for national development.' (D.A. Dadson, as quoted by Barrow, 1973.)
521. There have been and are various activities to establish technical, vocational training centres on a 'self-help' basis. Godfrey (1973) reports on a grand scheme set up in Kenya for this purpose. With the help of ITDG in Zaria (Nigeria) an 'Intermediate Technology Workshop' has been set up, which trains lower technicians and is financed mainly by the equipment the students make for rural hospitals. (See for designs Eaves and Pollock, 1974.) They have a need for more and better designs to work with, but typically they have no contact with the Ahmado Bello University in the same city. Universities are often seen as contributing to the 'building of a nation'. A practical way to interprete that is viewing them as teacher training centres (Rastad, 1969).

be made very clear; this can be done very well by including many "esoteric" or "irrelevant" alternatives, (ii) the contents of a course should be based on a thorough knowledge of the production systems present in and relevant to the surrounding environment.[523] The activities discussed in the next three subsections all support reaching this goal, which in fact involves broadening the traditional disciplines in two ways: in covering more production systems and by more integration with other disciplines.

The previous paragraphs relate to the contents of one particular course. On a higher level there is the choice of what to include in a curriculum. This, of course, is an insoluble problem, because one always wants more than is possible. But I think that in the context of

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522. At the University of Mexico an 'appropriate chemical technology' program originated in 1967 as a formal research project at the graduate school. The philosophy behind the program is that there is no basic dependency, but a lack of ability to negotiate. As part of the program a so called 'basic module language' has been developed. Chemical processes are not split up in unit operations such as fluid bed reactor and filtration, but into units which are more basicly descriptive such as liquid/solid separation and chemical transformation of gas. This provides a more open approach to possible adaptions in transferring a production system. 'La teoria de módulos bàsicos se originó en la necesidad de proporcionar un sistema rápido y eficiente para analizar un proceso dividiéndolo en sus partes fundamentales (en sus módulos básicos) para simplificar la adaptación de technología. Es decir, los módulos básicos son las partes en que se divide un proceso de acuerdo a las operaciones físicas o físico-químicas que se realizan a lo largo de él. Los módulos básicos de un proceso pueden dividirse en los siguientes grupos: .Mezclado; .Transferencia de calor; .Transporte de materiales).Transformación química;.Transformación física;.Separación molecular;.Separación mecánica;.Almacenamiento;.Transporte de energía.' Giral (1974). See also sections 2.4.2. and 3.3 on the work of this group.

523. 'Many of the universities and other institutions of higher learning in African countries still offered curricula which were traditionally colonial and as yet unmodified. Stronger orientation towards local problems and their solution, particularly as regards university curricula, was greatly to be desired.' (DSE, 1972). 'The limited experience at the Technology Consultency Centre has evidently indicated that such centres have a tremendous role to play in the industrial development of developing countries. In particular the experience has demonstrated the need for reviewing and adapting the traditional University curricula to suit the needs of developing countries.' (Ntim, 1974).

technology and development there are certainly neglected areas.[524] I do not think it is feasible that every university should include in its curriculum for chemical engineers a course which deals solely with how to adapt and transfer production systemsfrom one region to another. But, at this moment, as far as I know, on the whole world there exists not even one course devoted solely to this subject. A general problem is how to integrate other relevant disciplines into a curriculum (say, economics for engineers). It appears to be very difficult to do this in such a way that it becomes clear what exactly the relevance of the other discipline is, in working on an actual problem. I shall not pursue this point here any further.

6.4.4 Dissemination of information. I have discussed the structural aspects of information exchange in section 4.5.4. Universities could contribute to this problem in two ways:

(a) Taking the initiative to establish new specialist scientific journals. They can cater either for solely technical articles or techno-economical articles. Examples of the first could be "The Journal of Solar Drying" and "The Journal of Small Scale Ceramics and Cementious Materials Production". An example of the second category could be "The Journal of Transfer and Adaption of Chemical Production Systems". At this moment journals at this levél of specialisation are not possible, because - vide chapter 5 - virtually no R & D is carried out on these subjects. Hence, for the moment one has to start with journals covering, e g, all chemical or mechanical production systems. In screening articles submitted for such journals all conventional academic standards should be applied, to which should be added that in every article it should be clearly indicated for what environment the production system would be suitable. Because it will be difficult to uphold standards of quality, I think a good change in current practices of refereeing ar-

524. In US-AID (1976, p.27) it is proposed 'to assist LDC-institutions develop model appropriate technology design and lab courses in engineering and technology education.', and further 'Grants to develop multi-disciplinary programs in "development technology" at developing country universities.' Koppel and Hansen (1976) present a four year 'development technology curriculum', with a lot of economy and social-psychology and no technology proper. There is a danger that such a program is no more than an abstract encyclopedia of current opinions.

ticles would be that the editors send submitted articles to at least three referees in different countries. Further, articles could be published followed by critical comments of referees to give the readers insight into current prejudices. Of course, such journals do not aim at the grassroots. Their function is to make the subject an acceptable academic concern, thus contributing to a change of attitude. It may very well be that dissemination of information to the grassroots is more important than these elitist journals, but I do not judge universities capable of leaving their ivory towers so far as to directly communicate with the grassroots.

(b) More important than - or perhaps before starting - the journals, is the need for bibliographic services on the subjects that are not dealt with in establishment abstract services. The latter deal mainly with what is published in the official literature. As is apparent from the fifth chapter almost all information on traditional and non-large-scale production systems is contained in inaccessible reports and mimeographed notes of various, usually dubious, quality. Because these publications rarely pass some kind of screening test, it is not enough - and in some respects even dangerous - to just provide bibliographies (with or without abstracts). What is needed is a range of annotated bibliographies, which give a brief abstract and a critical assessment by one or more specialists. There will be a number of differences with the conventional procedure of critical reviewing. Firstly, a bibliography on a particular subject (say "biogas") will give many references to sources which are completely unreliable or useless. That is necessary because there are at the moment people relying on them and using them. Secondly, the editors may often have to decide that they cannot find a specialist to review a particular report. Publishing that information may have a stimulating effect. The annotated abstracts should appear at regular intervals, thus providing a form of continuity and supporting networks of information exchange that are now completely absent. Establishing such annotated abstracts should start on a small-scale covering very limited areas, but in-depth. It is therefore not a task for international organisations who can only engage in grand schemes and do not have the capabilities of establishing a network of annotators.

6.4.5 Research and development. On this I can be brief. From the survey of chemical production systems in the fifth chapter, it is clear that there is a wealth of R & D projects in which chemistry and engineering departments might engage. Whether it is very relevant what they are doing is disputable in view of the constraints discussed in the previous section.[525] But if they are doing R & D anyway, the "appropriate" subjects form a good basis for the other activities discussed in the present section. My opinion therefore is that appropriate R & D projects are only appropriate, provided (i) they support existing other activities (teaching, dissemination of information, consultancy), (ii) they are carried out in continuous contact with at least one potential area of application,[526] (iii) the utmost is done to keep in contact with other people working on the same kind of subject.[527]

6.4.6 Consultancy. This is perhaps a possible task of university staff-members most often stressed in the literature. At LDC-universities "Technology Consultancy Centres" are established in increasing

525. Independent of the direct practical relevance I think there is some sense in simply documenting traditional production systems that are now disappearing. As far as this is done at the moment, it is carried out by archaeologists and anthropologists, not by technologists. See for example on traditional techniques of iron-smelting in Africa. Wembah-Rashid (1973), Pole (1974), and references given there. Only "museum-people" are involved.

526. In cooperation projects between ODC- and LDC-universities, it is useful to distinguish projects that have as their main goal establishing an R & D potential at the LDC-university, and those that are cooperation projects based on some relevant research problem (say, the identification, isolation, and production of a potential drug from plants used in traditional medicine). The first type is most suitable for cultural dominance, and by far the most common. (The R & D is then usually a by product of an aid-project to set up a new department at the LDC-university.)

527. Reddy (1976), at that time working for UNEP made an interesting proposal of 'a network of institution-based projects on environmentally sound and appropriate technologies'. A network should be established because 'it is unlikely that any single team or group can develop environmentally sound and appropriate technologies with *global* relevance and validity.'

numbers. Staff-members of ODC-universities take part in "technical missions", and report after a visit of two weeks to region A what appropriate production systems should be established. I have my doubts about these activities. The "Technology Consultancy Centres" are usually isolated from the other activities at the university, and the technical missions are usually incapable of the task they have been assigned to do. There is nothing wrong with consultancy; it may even be the thing most needed. But it does not follow that a university is the best institution to provide it, unless it is a natural complement of other activities. This applies also to the microconsultancies dealt with by students and staff-members of ODC-universities in reaction to overseas queries channelled by the type of organisations discussed in section 4.5.

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'Chemical Technology for Appropriate Development' is basicly a critical review of the literature. It gives a conceptual analysis of so called appropriate technology and the choice of production systems for less-development countries. The role of about 40 organizations active in this emerging field are evaluated and the role of universities in this process of change is analyzed in some detail. Problems of transfer, adaptation, and (indigeneous) generation are discussed with special reference to chemical production systems and a review is given of a large number of physical and chemical processes relevant to the context of appropriate development.
The bibliography contains about 500 references.

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